npi
Electronic Instruments
for the Life Sciences

CellWorkS
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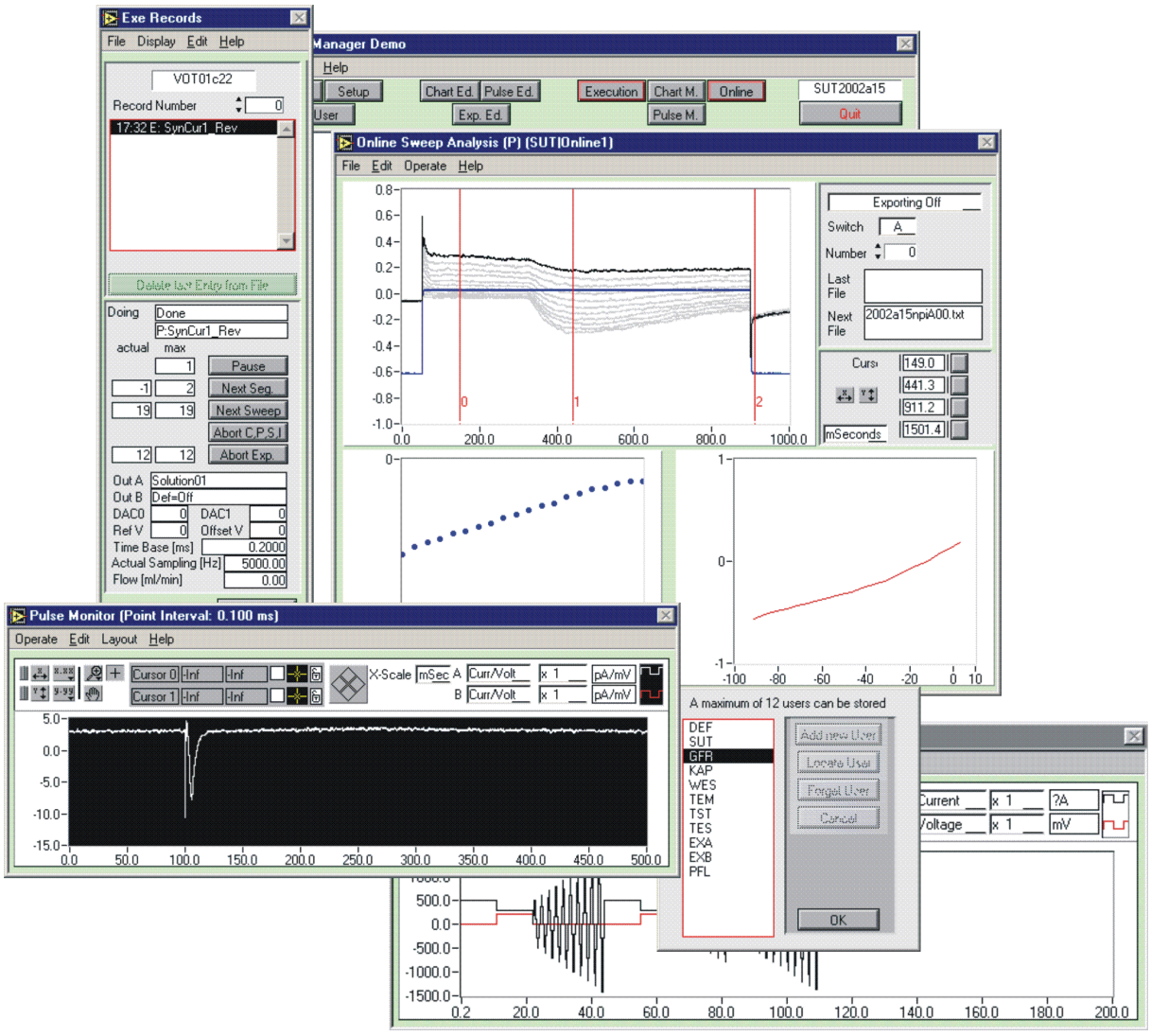
The Turnkey Software Solution for Experimental Control and Data Acquisition



Please read these notes before you start

Short Manual for

CellWorks Demo 5.5
CellWorks Lite 5.5
CellWorks Lite E 5.5

August 2003

Introduction

This short manual should help to install the CellWorks software package and to connect external devices to your data acquisition computer. It includes short descriptions of the several software modules and describes how to set the parameters for data acquisition and controls.

Important: Since some parts of CellWorks didn't change (with relation to version 4.0) they are described only very shortly in the "Short Manual 5_5". This refers to **Adaptation to the experimental environment** (CW Hardware, CW Setup and CW User module) and **Configuration of individual experiments** (CW Chart, CW Pulse and CW Experiment editor modules). These modules are described in detail in the "User manual Ver. 4.0".

Before you start to work please read the Safety Regulations (chapter 1) and the Software License Agreement (chapter 2).

The software package CellWorks consists of two main programs: the CellWorks program itself and the CellWorks Reader to view and export data (mainly CHART data) recorded with CellWorks. As a consequence of new data acquisition technologies we have adapted the CellWorks program to new hardware and now distribute three versions.

CellWorks Lite 5.5 is designed to be used with the data acquisition board series 1200 from National Instruments in conjunction with the npi breakout box INT-10 (or with the npi CellWorks amplifier TEC-03X-CW).

Note: National Instruments stops the production of PCI-1200 end of 2003. Therefore, CWL 5.5 will be the last version of CellWorks, which supports the PCI-1200.

CellWorks Lite E 5.5 is designed to be used with the Low cost E-series data acquisition boards from National Instruments in conjunction with the npi breakout box INT-20X (or npi CellWorks amplifier TEC-03X-CW).

CellWorks Demo 5.5 is not only a simple demo version. It can be used to replay experiments recorded with CellWorks for offline analysis of and to export data to other programs. Since CellWorks Demo is not protected by a dongle, it can be copied to any computer. Thus, further data analysis and replay of experiments can be performed offline at any place and by anyone.

CellWorks Lite and CellWorks Lite E differ only in the application of different data acquisition boards (PCI 1200-series or Low cost E-series) and the corresponding breakout box INT-10 or INT-20X. The additional hardware like digital I/O, valve drivers, pumps, amplifier communication etc. that compatible with CellWorks Lite is also compatible with CellWorks Lite E.

npi electronic 2003

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1. Safety Regulations

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Please protect the device(s) from moisture, heat, radiation and aggressive chemicals.

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The device is to be operated only at 115/230 Volt 60/50 Hz AC. Please check for appropriate line voltage before connecting any system to mains.
Always use a three-wire line cord and a mains power-plug with a protection contact connected to ground (protective earth).
Before opening the cabinet, unplug the instrument.
Unplug the instrument when replacing the fuse or changing line voltage. Replace fuse only with an appropriate specified type.

STATIC ELECTRICITY: Electronic equipment is sensitive to static discharges. Some input devices such as the analog inputs (Ai) of the PCI Low cost E series boards (National Instruments) are equipped with very sensitive FET amplifiers, which can be damaged by electrostatic charge and therefore must be handled with care. Static discharges can be avoided by touching a grounded metal surface when connecting or disconnecting such analog inputs. **Always turn power off when connecting or disconnecting electronic components.**

TEMPERATURE DRIFT / WARM-UP TIME: The system must be used only in a warmed-up condition (ca. 15-30 minutes after turning on the power). All analog electronic systems are sensitive to temperature changes. Therefore all electronic instruments containing analog circuits shall be used for recordings only in a warmed-up condition (i.e. after internal temperature has reached steady-state values). In most cases a warm-up period of 15-30 min. is sufficient.

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3. Hard- and Software Requirements

This chapter describes the hardware and software requirements for using CellWorks.

CellWorks is a stand-alone executable software package for the complete control of the experimental setup and data recording during electrophysiological investigations. It is programmed in LabVIEW, a high-level programming environment developed by National Instruments. Therefore, CellWorks is available in native code both for IBM-compatible PCs with Windows 95/98 or Windows NT 4.0/2000/XP and Apple Power Macintosh (Power PC) computers and can be used with a large variety of interface boards from National Instruments. CellWorks runs on Notebooks as well. Generally the hardware determines the performance specifications. Thus, performance depends on the hardware that is used.

3.1. Recommended computer systems

The following tables list the recommended minimum computer specifications required for CellWorks:

IBM compatible computer

CPU	Pentium, 233 MHz
RAM	64 MB
hard disk	200 MB free disk space
graphic board	VGA 800 x 600 pixel resolution, small fonts
operating system	Windows 9X / ME or Windows NT 4.0/2000/XP

Note: If you select - running a high screen resolution e.g. 1280x1024 - large screen fonts in Windows, the display of CellWorks may be corrupted!

Apple Power Macintosh computers

CPU	G3 Power Mac, 200MHz
RAM	64 MB
hard disk	200 MB free disk space
graphic board	VGA 800 x 600 pixel resolution
operating system	Mac OS 8.1, 8.6, 9.0

Note: MAC OS X is not supported!!

3.2. Interface boards

CellWorks Lite E was developed to run in conjunction with the National Instruments Low cost E-series boards. A variety of board types with different resolutions as well as sampling- and update rates are available. For operating the bidirectional communication of npi amplifiers, an additional digital I/O board (e.g. PCI 6503 with 24 digital I/O lines) is necessary. The next table gives three examples for system configurations:

application	board type and additional hardware	important specifications
minimal configuration	low cost E-series board PCI 6024E	max. analog input sampling rate 200 kS/s, max. analog output update rate 10 kS/s, 12 bit resolution
enhanced configuration for predominantly recording CHARTS with high resolution and enhanced solution exchange management (up to 96 valves)	PCI-6036E, and PCI DIO-96, npi VD-24 valve controller (valve drivers for up to 24 valves per controller), ALA BPS-8 (solution system for 8 valves per system)	PCI-6036E: max. sampling rate 200 kS/s, max. analog output update rate 10 kS/s, 16 bit resolution PCI DIO-96: 96 digital I/O lines (grouped to 12 ports) VD-24: valve driver for up to 24 valves, low noise and avoiding valve heating up technology BPS-8: solution system with 8 channels including reservoirs tubes valves, etc.
configuration for fast PULSE recording and npi bidirectional amplifier communication interface	PCI-6070E and PCI 6503, amplifier with additional standard interface board	PCI-6070E: max. analog input sampling rate 1.25 MS/s, max. analog output update rate 1MS/s, 12 bit resolution PCI 6503: 24 digital I/O lines (grouped to 3 ports)

4. Installation

This chapter describes the installation procedure for the software package CellWorks Lite E. Only the CellWorks Demo version can be executed directly from the CD (see the Read Me file for further details). All other versions have to be installed to the computer hard disk.
Before you start installing the hard- and software for CellWorks, the following parts must be available: Low cost E-series board from National Instruments, cable with SCSI female 68 pole connectors, hardware dongle, breakout box INT-20X or TEC-03 with additional I/O-unit, and the CellWorks CD. Optionally, npi amplifiers can be supplied with a digital bidirectional communication unit. In order to use this unit, a further digital I/O board with at least 16 digital I/O lines (e.g. PCI 6503 or PCI DIO 96, National Instruments) is required. For a complete hardware list see appendix, chapter 7.2.

Copy the

- CellWorks Lite E Folder
- Dongle driver Folder (only necessary for IBM compatible computers)
- NI-DAQ Installer Folder

to your hard disk and run the “hdd32.exe” program located in the HASP Dongle Driver Folder (only necessary for IBM compatible version) to install the dongle driver.
Next run “setup.exe” located in the NI-DAQ Installer folder and follow the instructions.
Shut down and switch off your computer system and install the PCI board(s).
For detailed information about the installation and configuration of the PCI board(s) please read the user manual shipped with the board(s).

After the installation of the data acquisition board, you have to check the board configuration in the "Measurement & Automation Explorer (MAX)" (located in the desktop folder). Start MAX and select the PCI-E-series board, e.g. PCI-6024E or PCI 1200 board from the device folder and make the following settings.

PCI 1200: AI: -5.0V - +5.0V, Non referenced single ended; AO: bipolar; all other settings: default values.

E-series: AI: -10.0V - +10.0V, Non referenced single ended; AO: bipolar; all other settings: default values.

In MAX you can select "Test Panels" for checking the data acquisition board. Please do so and perform as much tests as possible. **No** error must occur. If you get an error please uninstall all NI related soft- and hardware and go through the installation routines again. If you still get an error, contact npi electronic.

Note: npi highly recommends the use of NI-DAQ 6.9.3 for all Windows versions. For MAC OS the NI-DAQ 6.14 or higher must be installed.

Note: We recommend installing the PCI Low cost E-series boards as far away as possible from the graphic board.

Switch off the system again and install all other hardware components: dongle, breakout box, amplifiers,...(Figure 1)

Note: The dongle types for PCs and Macs are different. The PC dongle is connected to the parallel port, the Mac dongle is connected to the ADB. For use of CellWorks on Macs without an ADB port (e.g. G4), an iMate adapter is required. Please contact npi for details. Before connecting or disconnecting the dongle switch off the computer. Otherwise the computer or dongle could be damaged.

Typical installation with control of valves, pump and the T.I.L.L. monochromator.

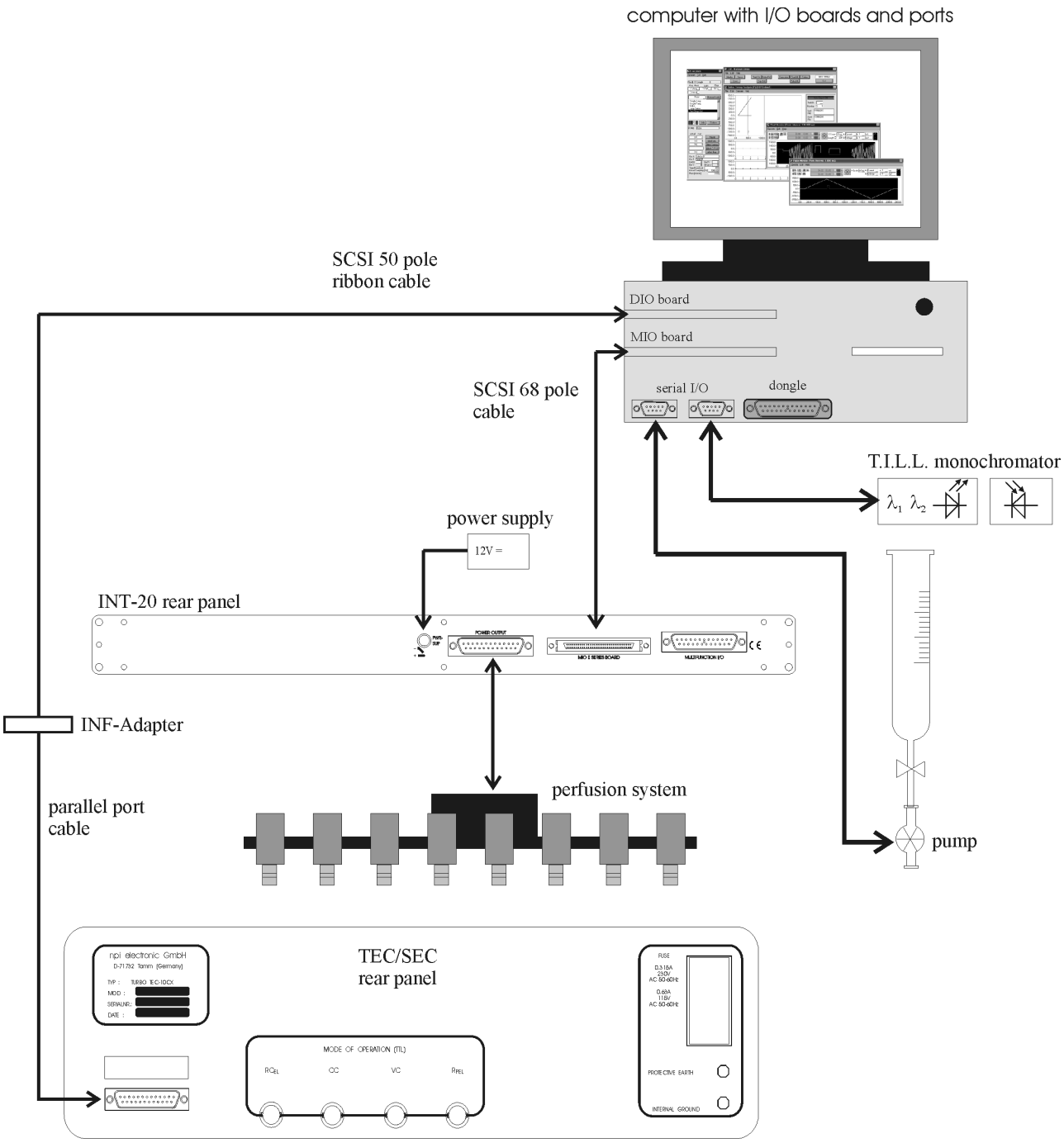


Figure 1: assembling the hardware

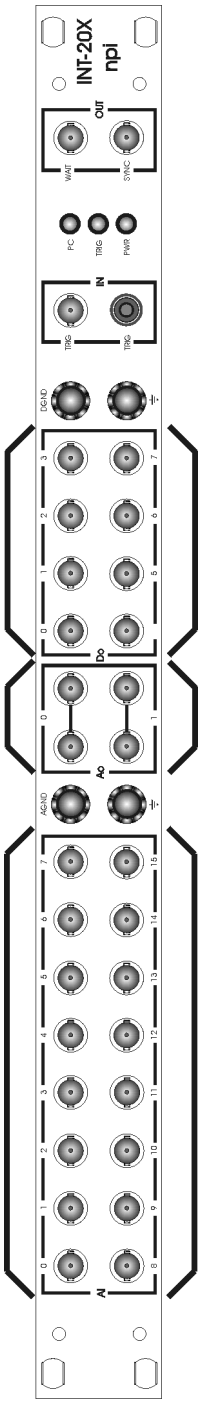


Figure 2: INT-20X front panel

Front panel			
Number	**Short name**	**Signal name**	**Description**
1	Ai0...Ai15 (ACH0...ACH15)	Analog input channels (Analog Input)	16 BNC connectors providing the 16 analog input channels of the E-Series board.
2	AGND (AISENSE)	Analog input ground (Analog Input Sense)	This connector supplies the reference point for all analog input channels.
3	GND	Ground	Chassis potential.
4	Ao0...Ao1 (DAC0...DAC1)	Analog output channels (Analog Outputs)	These BNC connectors provide the 2 analog output channels of the MIO board.
5	Do0...Do7	Digital output ports (Digital I/O)	These output ports provide the 8 digital lines from the E-Series board.
6	GND	Ground	Compare to number 3.
7	DGND (DGND)	Digital ground (Digital Ground)	This connector supplies the reference point for all digital signals.
8	TRIG	Manual trigger	This push button triggers the MIO board manually
9	TRIG (TRIG1)	Trigger input	This BNC connector provides the timing signal PFI1/TRIG1 from the E-Series board for connecting an external trigger device with active low logic.
10	PC, TRIG, PWR	PC connection, Trigger, Power supply connection	LED PC indicates the connection between the computer and the breakout box (computer must be switched on). LED TRIG indicates the Trigger status (green = trigger active, red = waiting for trigger). LED PWR indicates that an external power supply is plugged in.
11	WAIT (GPCTR1_OUT)	"Wait for Trigger" signal	LOW (0 V) by default. Gets HIGH (+5 V) if CellWorks waits for a trigger and remains high until STARTSCAN has been started (see Figure 3). ***Note***: GPCTR1_OUT is set by software and therefore not very precise (a few ms).

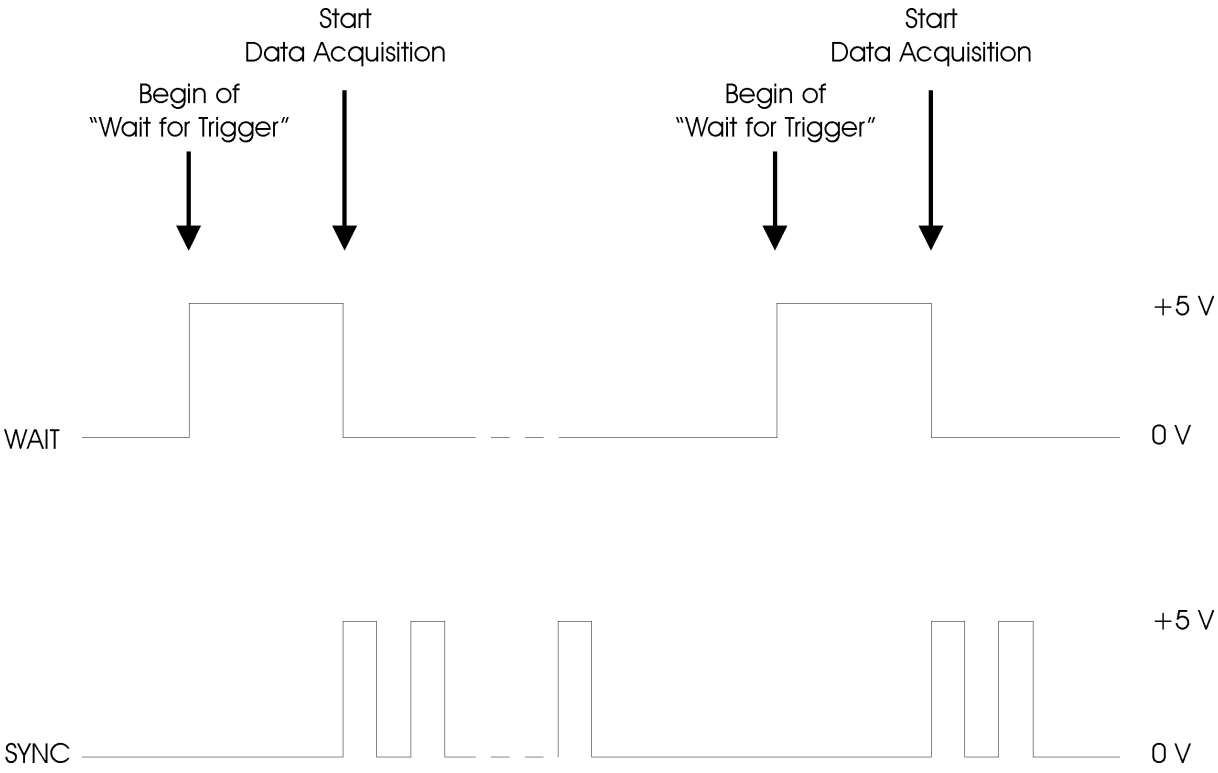


Figure 3: time course of trigger out signals

CellWorks provides a variety of possibilities of controlling amplifiers. Some examples of how to connect npi amplifiers and of basic software parameter settings are described in the appendix of this manual, chapter 7.3.

5. How to Use CellWorks

The following chapters describe the structure of CellWorks (CW) and give an overview of the main parts. The idea is to provide enough information for the user to get started with CellWorks and to perform first experiments. While reading this chapters we recommend the user(s) to sit in front of a suitable computer system and follow the instructions directly in CellWorks.

Before you start CellWorks, make sure that the installation and configuration procedures have been completed (see chapter 4).

5.1. Basics and CW Manager

This chapter briefly describes the structure and some basic concepts of CellWorks (CW) like the subeditor technique, and shows how to operate the modules of CellWorks using the CW Manager. For a complete description of the basics of the user interface refer to CW 4.0 Manual, which is on the CellWorks CD as well.

As mentioned above the software package CellWorks consists of two programs:
CellWorks, that we distribute at the moment in three versions (CellWorks Lite 5.5, CellWorks Lite E 5.5 and CellWorks Demo 5.5) and CellWorks Reader 3.6, that is designed to view and export data recorded with CellWorks (mainly CHART data; PULSE data should be exported using the Online analysis modules, see chapter 5.8). CellWorks Demo and CellWorks Reader are not protected by a dongle and can be copied and given to any other person.

A fundamental concept of the CellWorks user interface is the use of subeditors which open after double clicking the corresponding editor field or table. In many cases an editor window is opened where additional settings can be carried out.
You will find subeditors in many CellWorks modules and you can identify them by a small red line that surrounds the subeditorial field.

CellWorks is a modular structured program. The central module is the CellWorks Manager (CW Manager) which is automatically launched when CW is started. The CW Manager can call all other modules, which are divided into three different categories:

- **Adaptation to the experimental environment** (CW Hardware, CW Setup and CW User module)
- **Configuration of individual experiments** (CW Chart, CW Pulse and CW Experiment editor modules)
- **Execution of experiment**s (CW Execution, CW Chart and CW Pulse Monitor, several CW Online modules)

The “Quit” button in the right lower corner of the CW Manager terminates the program if all other modules are closed. The indicator above shows the status of the program and the name of the active user folder.

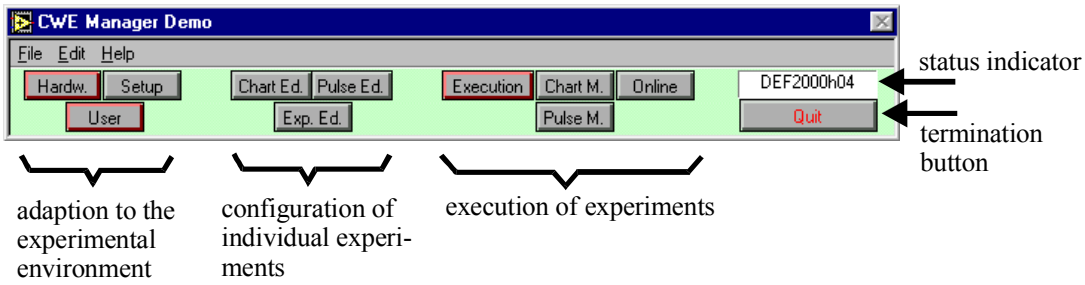


Figure 4: CW Manager

Modules can be launched by clicking their corresponding buttons. Every module header includes a menu bar similar to other Windows- or Mac programs with commands. Short cuts are available for most of the menu commands, for instance to close a module press *"control + w"*.

Several modules can be loaded into memory at the same time. An active module is marked by a red line surrounding the module button. When multiple modules are opened concurrently, it is possible that conflicting parameters are created by the user. To avoid such problems, the concurrent opening of modules, which are dependent on each other, is restricted. For example, when the CW Execution module is open the CW Chart Editor can be opened only in a "Read only" mode, i.e. the user can check the settings of parameters but cannot alter them.
The next figure shows the common procedure for planning and executing an experiment using the CW modules. First, the hard- and software is configured and adapted to the experimental setup. Next, a user is created and for this particular user an individual environment is defined. Then, the CHART and PULSE protocols for this user are assembled and experiments are planned. Finally, an experiment is carried out with the options of monitoring data acquisition, using online analysis or exporting data.

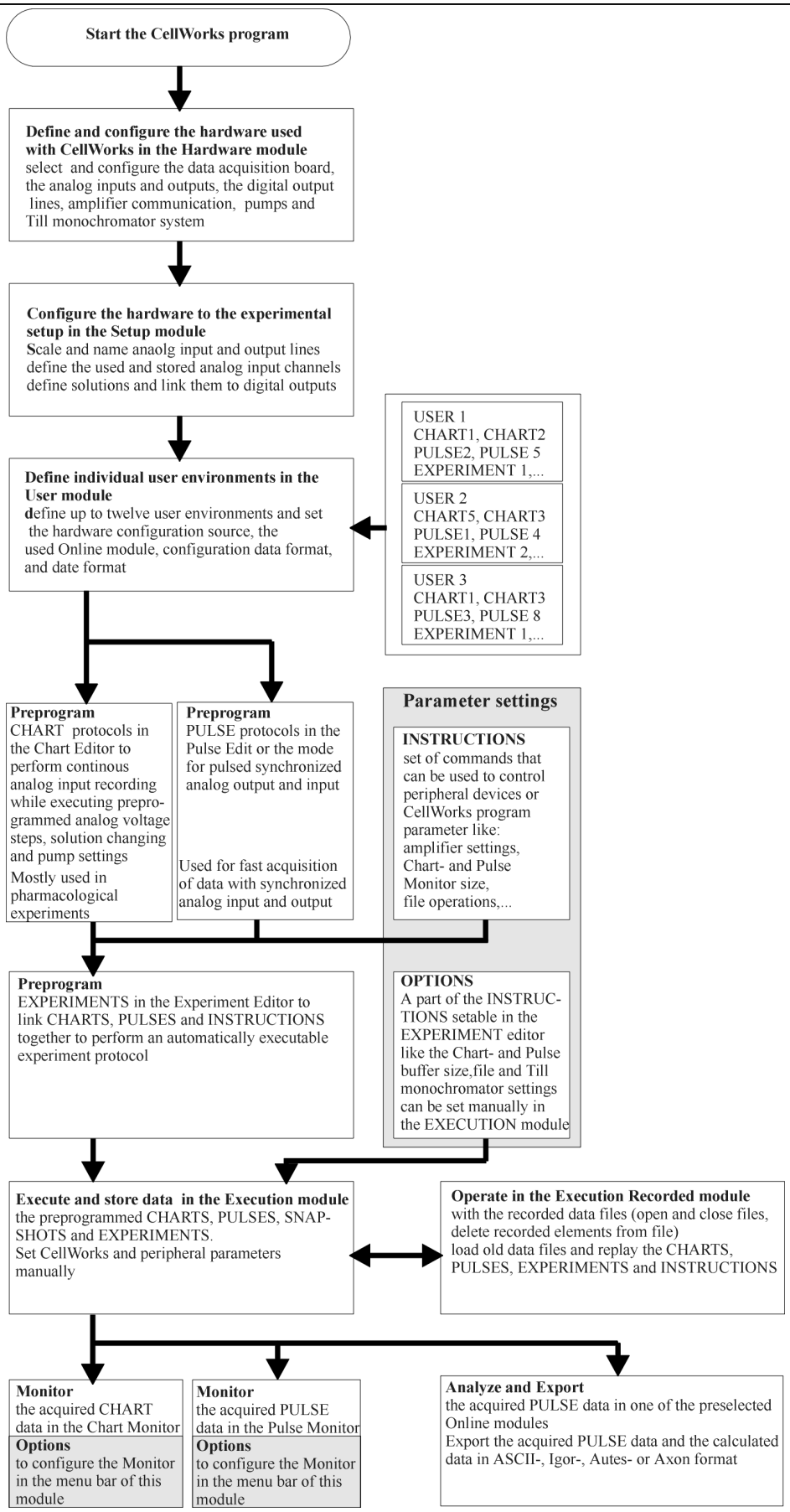


Figure 5: Flow chart of using the CW modules

5.2. Configure the hardware in the Hardware module

This chapter briefly describes how to configure the existing hardware (interface boards) using the CW Hardware module. If you use the Demo version you can skip this paragraph, because the Demo Version has preconfigured hardware and these settings have no effect (please read also the ReadMe file on the CellWorks Demo CD). For a complete description of the hardware editor module refer to CW 4.0 Manual, which is on the CellWorks CD as well.

During start, CellWorks checks whether the actual hardware configuration matches the configuration stored in the hardware configuration file. If CellWorks recognizes different hardware (which is e.g. the case when starting the CW Manager the first time), this is indicated by a red, blinking field in the CW Manager status field and the appearance of the error message "Error -99010 Possible reasons ...". In this case, you have to launch the CW Hardware module and select valid settings. The hardware settings should be set to “DEF” (default) user.

Starting CellWorks the first time

- Log-in as user “DEF” (default). An error dialog box will appear after login (see above). Read the instruction and OK the dialog box.
- Click the “Hardw” button of the CW Manager to open the CW Hardware module. The “Board + Interface Configuration” text field contains four subeditors divided by dashed lines. You **must open each** of these subeditors by double clicking into the text fields (even if you do not change anything) and select valid settings. You will find basic settings for a variety of npi hardware in the appendix.
- At this time (after the hardware configuration) we recommend a first test to check whether the software and the DAQ board are working fine. In chapter 5.8 is an example of how to start a PULSE.

The right half of the module window contains parameter settings, e.g. for adjusting the speed (flow) of external "Pumps" via the serial ports of the computer (Mac: "Modem" or "Printer" port, PC: "COM 1"-"COM 8") and the configuration of digital (TTL) "Output" lines to control further external devices like valves to apply solutions automatically (Figure 6). If the external devices require more than one digital line for complete software control, the user can define "Groups", i.e. a collection of up to four digital lines that are associated with the group name. Thus, it is possible to associate a single "Output" with up to twelve TTL lines (four individual lines, plus two "Groups" of lines). See the CW Manual 4.0 for a complete description of the output settings.

After closing the module a dialog box opens, where the user can save all settings to a hardware configuration file or quit the module window without saving. Nevertheless, the actual configuration settings remain in memory for this CW session. Thus, one can test and probably alter the settings and save them to the configuration file not until everything works well.
After initial configuration, the CW Hardware module will probably be accessed rarely. Consequently, configuration of those terms and elements of the hardware environment that may change from experiment to experiment, can be made in the CW Setup module.

Note:	Once the three environment configuration modules (Hardware-, Setup- and User-module) have been configured, we recommend to create a new USER. At this time also make a BACKUP of your default configuration files (chapter 7.4). This is perhaps the most difficult part in setting up CW, but usually HW configuration rarely needs to be changed. For a number of configurations, especially for amplifier interfacing, you will find examples in the appendix.

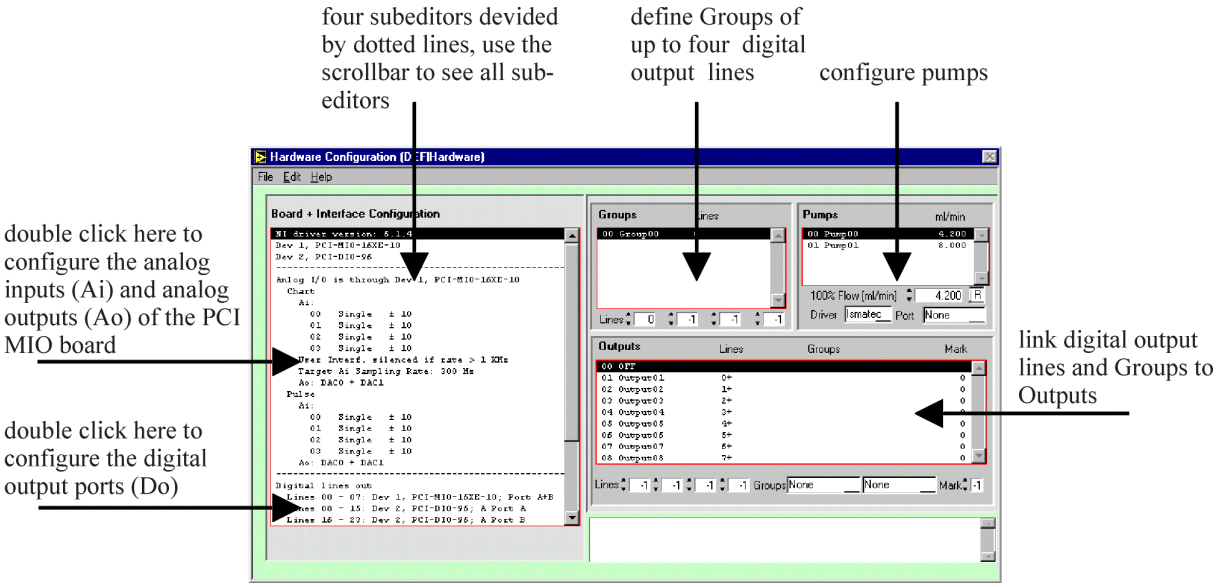


Figure 6: CW Hardware module

Sample settings for a setup consisting of: PCI-6024E, npi amplifier TEC-10CX (with the additional bidirectional interface), npi breakout box INT-20X and the 8 channel perfusion system BPS-8 from ALA scientific

Start Hardware module, double click all four "Board + Interface Configuration" subeditors and set the parameters as shown Figure 7 - Figure 10:

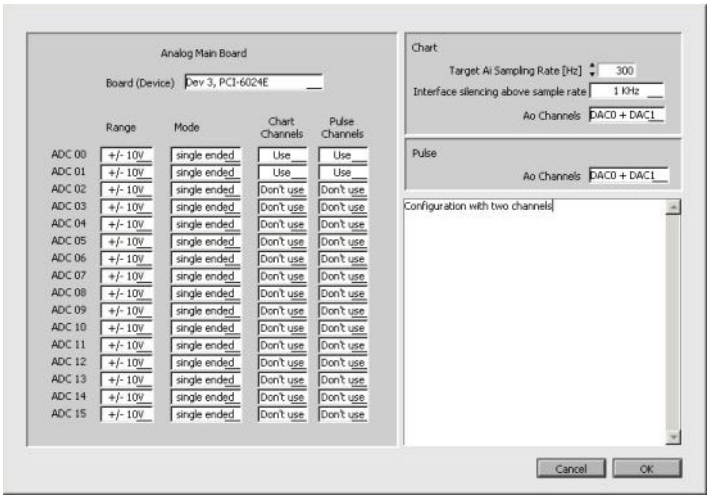


Figure 7: board configuration subeditor

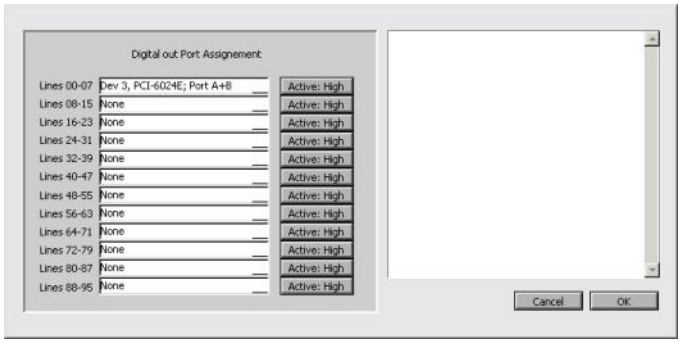


Figure 8: digital output lines (Do) subeditor

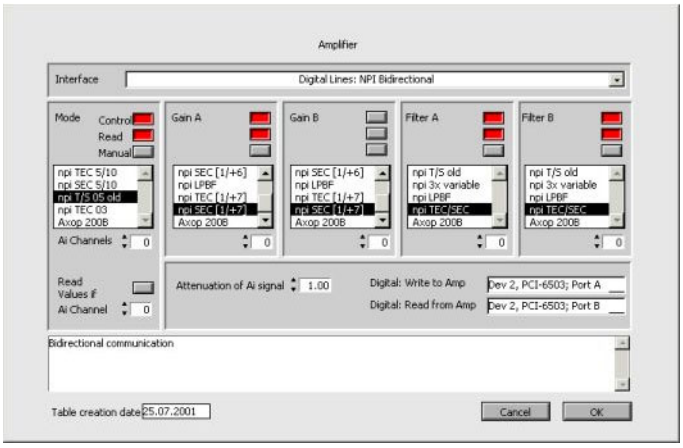


Figure 9: amplifier subeditor

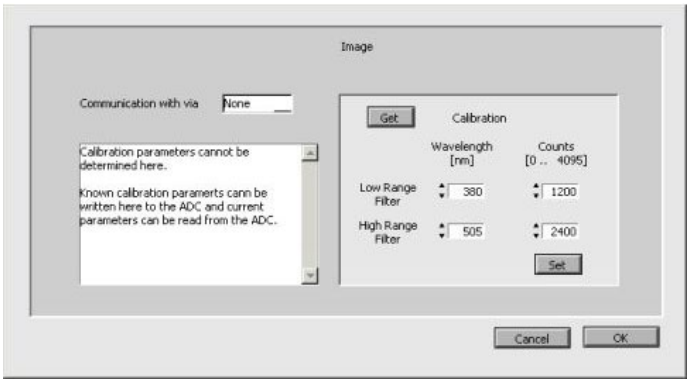


Figure 10: T.I.L.L. monochromator subeditor

Note:	You have to open the "Till monochromator" subeditor even if this device is not installed at all. Please close the subeditor by clicking OK.

5.3. Configure the experimental setup in the Setup module

This chapter describes how to adapt the existing hardware to the experimental setup using the **CW Setup** module (Figure 11). In this module, “Software gain factors” are defined to adapt the scaling of diagrams, monitors etc. to the connected hardware. This is important for correct saving and exporting of data as well. In addition, in the CW Setup module you define analog and digital outputs. The user can assign outputs to solutions and group them in lists to define a complete sequence of solution changes in an experiment.

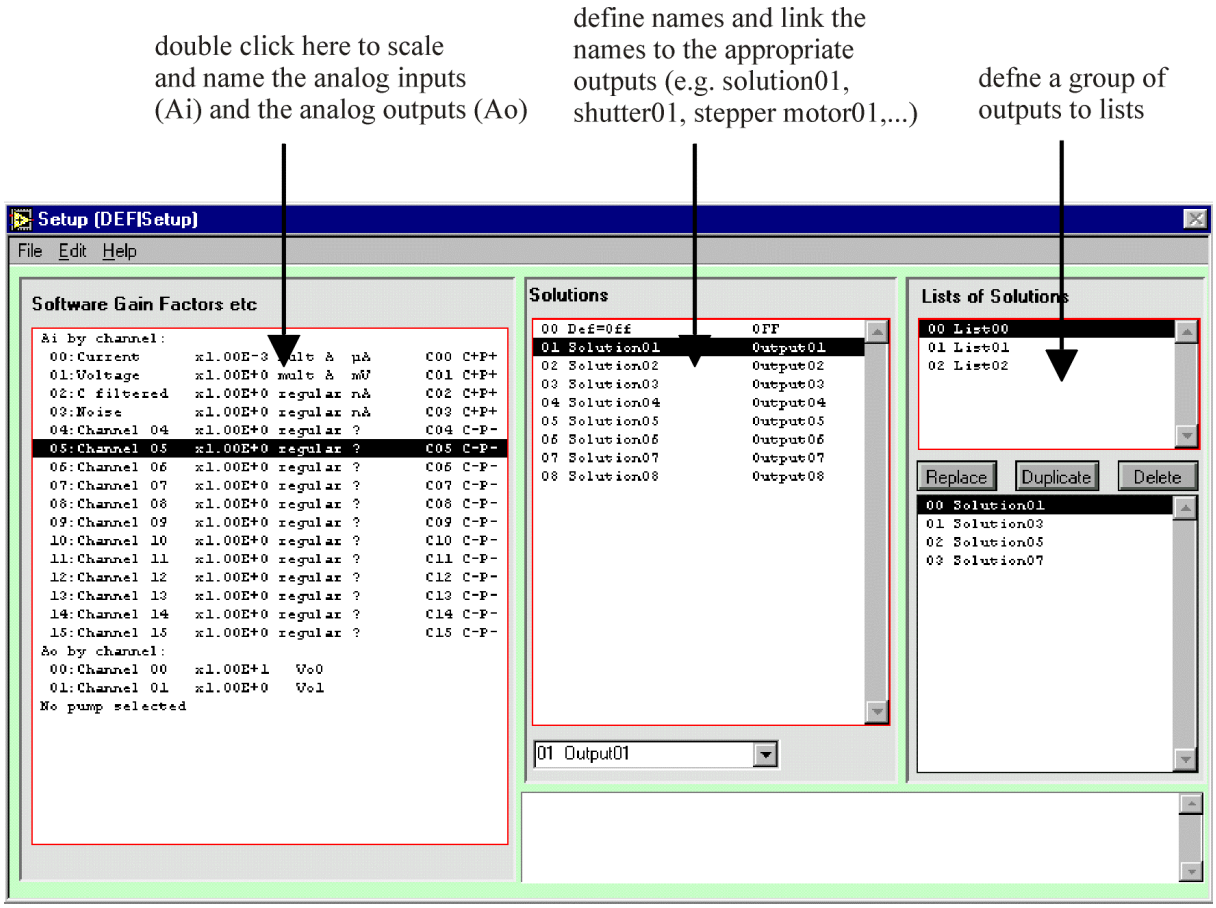


Figure 11: CW Setup module
the parameters listed in the “Software Gain Factors etc” table fit to a TEC amplifier

In order to configure the analog input (Ai) and analog output (Ao) channels of the hardware environment that may change from experiment to experiment, launch the CW Setup module and open the "Software Gain Factors etc." subeditor. Here, you can name the different Ai and Ao channels and - more important - select which of the physically available channels ,defined in the CW Hardware module, will be used and stored to file on the hard disk. "Gain Factors" and "Sensed Gain" (telegraphing) multiplication factors for the individual analog channels are defined as well (Figure 12). The appendix has some sample settings for a variety of npi instruments.

Another set of important configuration parameters are the "Solutions". These settings are used to determine user defined solutions or other devices that can be controlled by digital output lines (e.g. shutter of a microscope or stepper motor controller) and to assign them to "Output" names (the outputs have to be set in the CW Hardware module (chapter **5.2**). Furthermore, the user can group solutions in lists to define a complete sequence of solution changes in an experiment. In a chart consisting of several sweeps, the solutions in the list will be changed consecutively sweep per sweep as they are listed, e.g. if the list contains solution 1, 2 and 3 (in that order), in sweep 1 solution 1 will flow, in sweep 2 solution 2 will flow and in sweep 3 solution 3 will flow. If a chart consist of more sweeps than solutions in the list, the valve will be closed (Def = off). For a detailed description see CW Manual 4.0.

Note:	CellWorks generally refers to list items by their position and not by their name. Also note that CW starts counting with 0 (zero) and not with 1.

Sample settings in the subeditor "Software Gain Factors etc." for a npi TEC amplifier (e.g. TEC-10CX)

Amplifier data:

COMMAND INPUT and CURRENT STIMMULUS INPUT:	/10mV
POTENTIAL OUTPUT PEL:	*10mV

Open the CW Setup module and the subeditor "Software Gain Factors etc." and set the parameters according to the settings shown in the screenshot below.

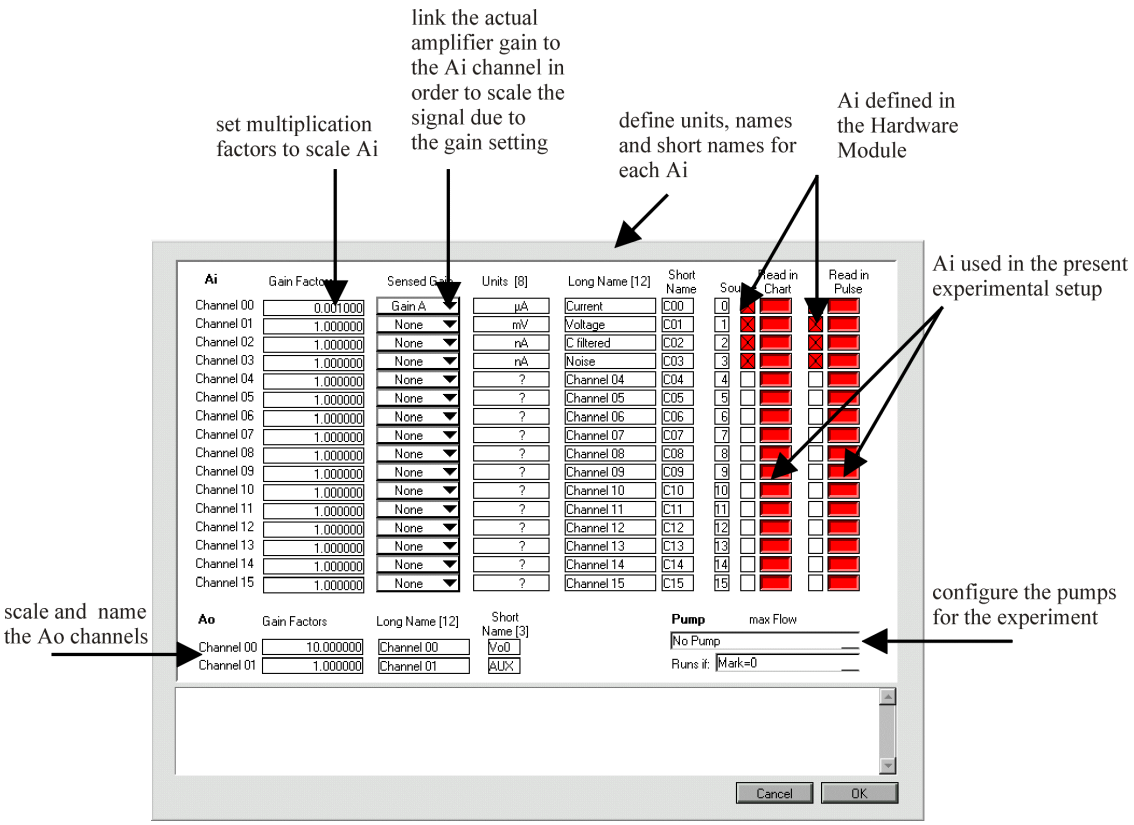


Figure 12: CW Setup module: basic settings for a npi TEC amplifier

Note: All signals are scaled to mV (an input of 1V and a Gain of 1 will be indicated as 1000 mV)
The default scaling of the npi amplifier *10mV current output is pA for SEC-05/10 and nA forTEC-03/05/10. If you want to have the TEC current displayed in µA and the SEC current in nA the scaling factor must be 0.001.

5.4. Define the users in the User module

This chapter describes the multi user feature of CellWorks, and how different users can be created or loaded in the **User module**.

When CellWorks is started, the CW Manager always loads a user-related configuration ("DEF" is the default user configuration setting) from a configuration file in the user directory. It contains information of all individual parameters and configurations necessary to perform experiments. Thus, each user can have her/his own set of preferences and configuration settings, which is very helpful if the experimental setup is shared by several persons.

The initial hardware and software configuration should be done as “DEF” user. However, after finishing this initial configuration (see above), we strongly recommend creating a new USER, i.e. to perform further configurations and experiment settings under different USER names. This has the following advantage: the “DEF” user has its own directory, which contains pre-set configuration files (e.g. for CHARTS and PULSES), as well as folders for data and export files. If you make further changes of CW configurations (i.e. if you change CHART, PULSE or EXPERIMENT parameters) and you are logged in as “DEF”, your default configuration files are overridden by the new settings. But, if a new USER is created, the actual configuration files from “DEF” are copied to the new USER. Thus, if you are logged in as this new user, all changes you make refer only to this user and the default configurations are kept. It is possible to create up to 12 USERs, all with their own, individual configurations (e.g. solutions, CHART- and PULSE protocols...). Only the first three letters of the username are displayed in the status window of the CW manager (Figure 4) and are used to code filenames in the data and export directories. Therefore we recommend you use only three letters as username.

Create a new USER

- Open the CW User module by clicking the “User” button in the CW Manager window and then click the “Change User” button.
- Double click a user name in the left field with the red frame to enable the buttons at the right.
- Click the “Add new user” button and follow the instructions (the first three letters of the USER folder name are used as USER initials). When a new user is created, a subdirectory for the new user is created and the configuration files from the DEF user are copied to this directory.

Source of the configuration files

The source of the HARDWARE-, SETUP-, CHART- PULSE- and EXECUTION configuration files is selected in the User module by the corresponding buttons “Hardware”,

"Setup",..... The user can decide whether the corresponding configuration file is taken from the "DEF" folder (Default file) or from the "USER" folder (User File). We recommend always load the hardware and setup configuration from the "DEF" (default) user (Figure 13). This avoids configuration problems and makes it easier to adapt new hardware to **all** users.

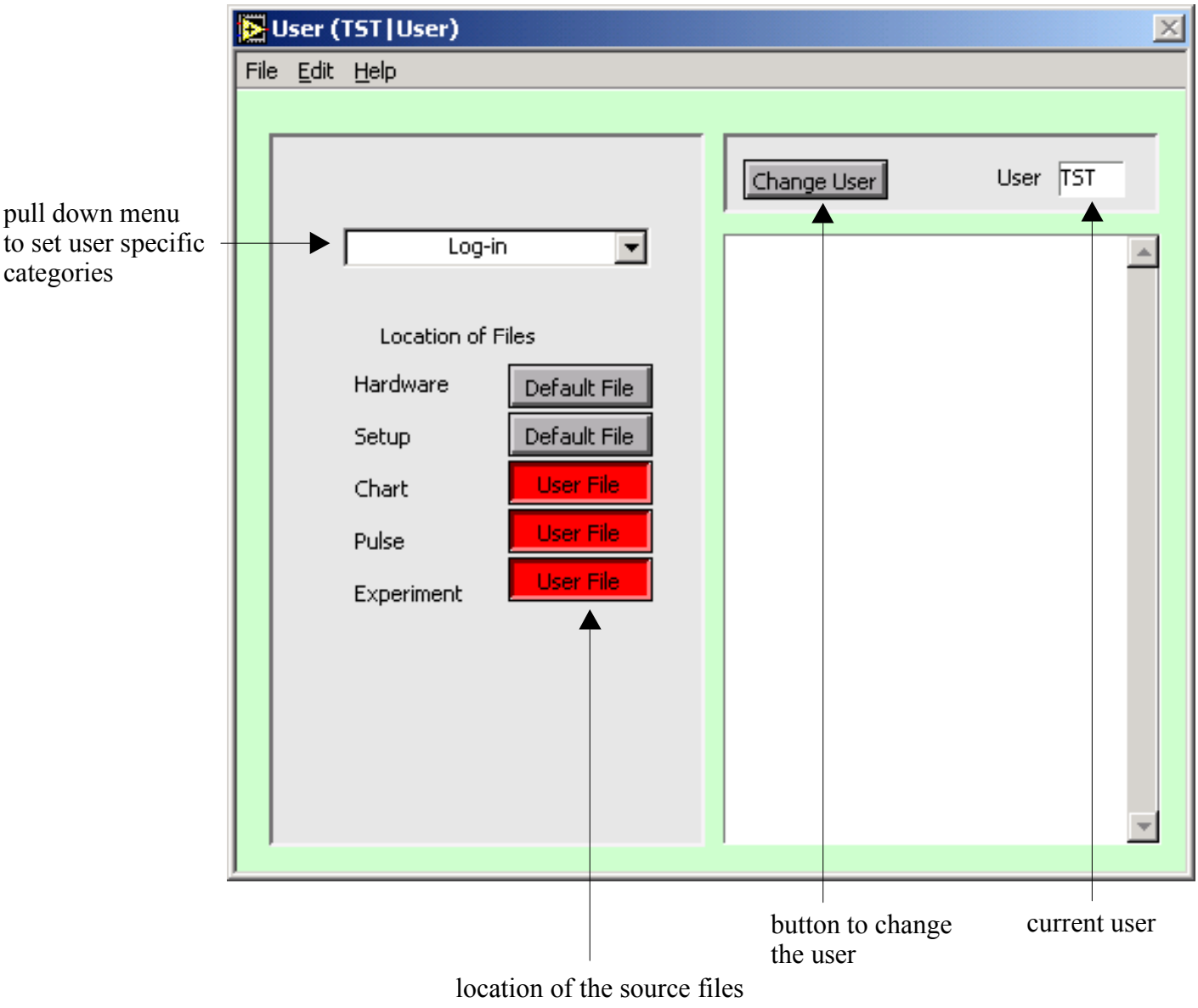


Figure 13: CW User module

Configuration file format and date format

In CellWorks it is possible to export the configuration files and comments in simple text, Word or Word Perfect format. The year format can be displayed and stored with two or four digits (year 2000 or year 00). In order to choose the text format of exported configuration files and the date format, select "Date and Text" from the popup menu and set the parameters as desired. CellWorks gets the date directly from the computer clock and it cannot be changed manually within the program.

Note:	If there are major problems please log in as Default USER ("DEF") and rebuild your user environment step by step. Even better, create a backup copy of a working Default USER configuration for convenient restoration of a running system.

Select an Online module for a user

- Open the CW User module by clicking the "User" button in the CW Manager window, open the pull down menu and select "Online Modules".
- You see a list with four available online modules.
- Select one of them.

When the "Online" module is opened the next time the selected module is displayed.

Note:	You cannot load external modules in this version of CellWorks.

5.5. Edit CHART sequences in the Chart Editor

This chapter briefly describes how to create and modify CHARTS, continuous analog input recordings, slow analog output signals and digital lines in the **CW Chart Editor**.

CHARTS are used to perform continuous analog input (Ai) recordings while writing slow analog output (Ao) signals, controlling pump speed and/or digital (TTL-) output lines, e.g. to apply solutions via valves or control stepper motors. Manipulation (i.e. editing, changing, creating, saving, etc.) of CHARTS and their parameters are carried out in the CW Chart Editor (Figure 14).

Note:	The basic procedure of manipulating CHARTS (and PULSES too) is to duplicate an existing CHART and then configure the new CHART. You cannot create a new CHART without copying an existing one.

How to create a new CHART

- Open the CW Chart Editor with the corresponding button in the CW Manager.
- Double click a CHART name in subeditor field (left), where all available CHARTS are displayed. CellWorks provides some default CHARTS (these CHARTS can be edited, deleted and duplicated in order to generate new ones). The subeditor window opens.
- If the "Order Locked" button is red, turn it to gray by pushing it. Now the "Duplicate" and "Delete" buttons are available.
- Click the button "Duplicate" and rename the copied CHART in the small upper text field.
- Move the new CHART to the desired location in the list (we recommend always adding new CHARTS at the end of the CHART list).

Note: CellWorks generally refers to list items by their position and not by their name.

- OK the subeditor. The new CHART will be added to the CHART list.

Now you can modify the new CHART as desired. You can define two independent groups of digital outputs (the organization of digital output lines is performed in the "CW Setup" module (see chapter 5.3), set analog output (Ao) values, increments and delays for each segment (see below).

CHARTS are organized hierarchically, i.e. they consist of one or more sweeps, that are build up by one or more segments. Thus, segments are the smallest components of a CHART that can be configured independently of each other (the number of segments within a CHART is not limited). The parameter settings of three CHART segments are shown in the window. If the CHART consists of more than three segments the user can move them by the (+) or (-) segment mover buttons. Segments are duplicated, deleted or inserted using the (+) button beneath the segment mover buttons. The configuration of the CHART is visualized by a CHART trace on the graph in the lower part of the module window. Various display parameters are available for suitable monitoring of CHARTS including a "Play" button for CHARTS with more than one sweep.

A very important CHART parameter is the "Time Base" which can be found in the "Timing" subwindow. This parameter defines the temporal distance between the acquired voltage data points. If "Time Base" (calculated in ms) is higher than the "Target Ai Sampling Rate" of the CW Hardware module (calculated in Hz), the latter value defines the real sample frequency. If "Time Base" is lower, CellWorks selects a suitable sampling rate close to "Target Ai sampling rate" and performs an averaging (oversampling) of the acquired voltage data points. This leads to data reduction and improvement of the signal-to-noise-ratio.
In the "Timing" subwindow the user can also set the number of sweeps per CHART, the interval between two sweeps and two markers. The markers are used to mark a subset of segments, e.g. segments 1-3. A value of –1 means "disabled". In the CellWorks Reader (see chapter 6) and/or in Online modules (see chapter 5.9) these markers are used to show and/or export only parts of sweeps.

For a more detailed description of the parameters of CHARTS see CW Manual 4.0.

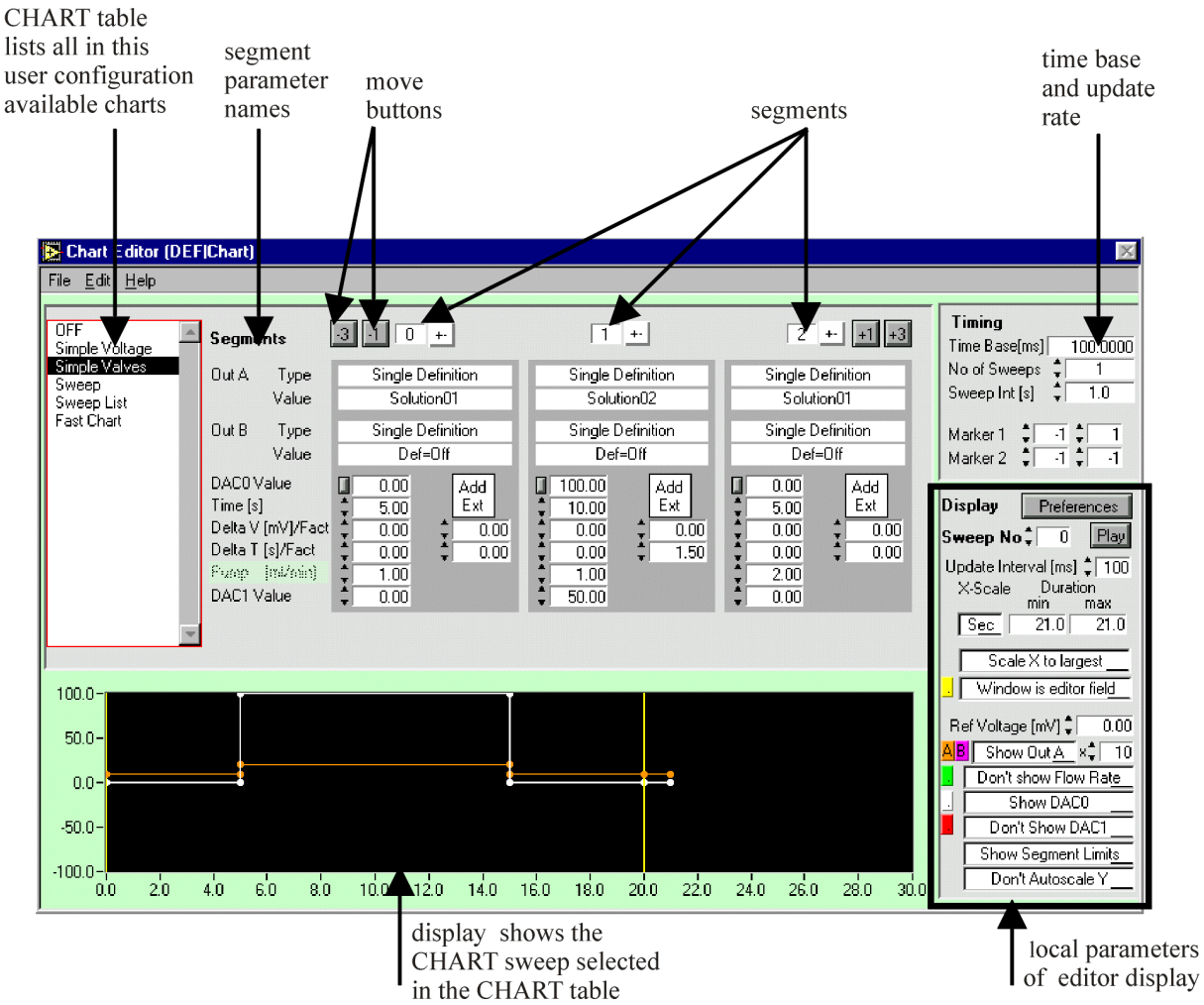


Figure 14: CW Chart Editor

5.6. Edit PULSE sequences in the Pulse Editor

This chapter briefly describes the **CW Pulse Editor** which is used to define fast voltage protocols (pulses or ramps) for the two analog output channels Ao0 and Ao1 of the interface board and simultaneously perform synchronous Ai recording.

The Pulse Editor window is very similar to the Chart Editor window (see chapter 5.5).
As in CHARTS, segments are the smallest (temporal) components of PULSES. The parameter settings of five pulses are shown in the module window (see Figure 15). The list at the left side contains the available PULSES and after selection of a PULSE the parameter settings are updated immediately. In addition, CellWorks reads these parameters and displays the corresponding traces in the graph, which has various display and scaling features. For DAC0 seven parameters can be set for each segment: Segment Type (Constant or Ramp), value, time and four parameters to define increments for voltage and/or time. Furthermore, all voltages can be set in relation to a "Reference Voltage" to simplify pulse protocols for different holding potentials, e.g. the user can define voltage steps (defined as step amplitude) for an I/V curve in relation to a certain holding ("Reference") potential. This "Reference" potential is for display only. The physical "Reference" voltage output at DAC0 has to be set in the "Manual" mode subeditor in the Execution module. For DAC1 you only can set delay, value and length. DAC1 is preferable for generating trigger pulses.

In the “Timing” subwindow the “Time Base” value defines the sampling rate. In contrast to CHARTS, no oversampling can be performed. As in CHARTS, a PULSE can consist of more than one sweep and in the “Timing” subwindow the user can set the number of sweeps and the interval between two sweeps. Markers can be set as well. They are used in the Pulse Monitor to display only parts of sweeps and in the Online Modules to display and/or export only parts of sweeps.

For a more detailed description of the parameters of PULSES see CW Manual 4.0.

To edit, create, change or delete list items, open the subeditor by a double click to one of the PULSE names in the list. CellWorks comes with several predefined PULSES which should be used to create your own versions.
The basic procedure is the same as in the CW Chart Editor. First, take an existing pulse, duplicate the pulse in the subeditor and then modify the pulse parameters according to your needs.

How to add a new segment to a PULSE sweep

- Open the Pulse Editor with the corresponding button in the CW Manager.
- Select one of the available PULSES, e.g. “Simple Ramp”.
- Click the (+-) button at the segment 2. A popup menu appears. Select “Duplicate” from the popup menu. A further segment is generated with identical parameters. The Pulse Editor display should now show the pulse as shown in Figure 15.

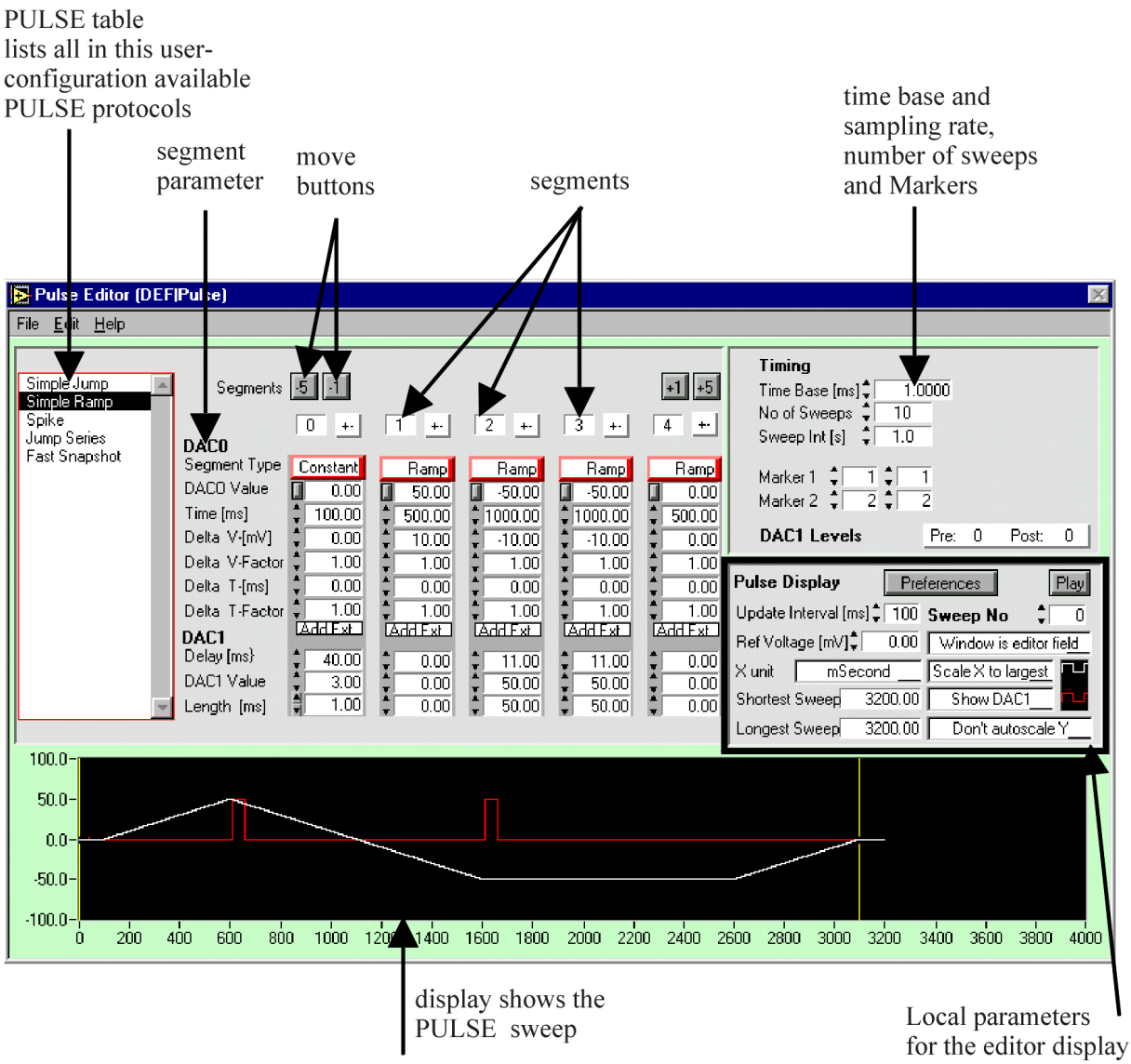


Figure 15: CW Pulse Editor after adding a segment in the example above

Note:	SNAPSHOTS are PULSES for Ai with very high sampling rate only (Ao is disabled). In some Low cost E-Series boards (e.g. the PCI-6024E) the maximum analog input sample rate is higher than the maximum update rate of the analog outputs. Therefore, before working with fast PULSES (sample frequency >10kHz) refer to the technical limitations described in the board documentation. You may also wish to consider using SNAPSHOTS instead of PULSES.

5.7. Linking CHARTS, PULSES, SNAPSHOTS and INSTRUCTIONS to EXPERIMENTS

This chapter describes the **CW Experiment Editor** which is used to link the preprogrammed CHART- and PULSE protocols. The **CW Experiment Editor** also controls hard- and software settings via INSTRUCTIONS to perform automated execution of complex experiments.

CellWorks allows scheduling of previously defined CHARTS and PULSES, as well as additional INSTRUCTIONS and SNAPSHOTS, in any order for complete control and automatic execution of a whole experiment. The user can assemble CHARTS, PULSES, SNAPSHOTS and INSTRUCTIONS to a schedule list called EXPERIMENT in the CW Experiment Editor. Remember, that SNAPSHOTS are PULSES without analog output (Ao) signal generation. SNAPSHOTS can be used for discontinuous, pulsed Ai recordings, perhaps in combination with an external stimulus generator. The order of execution of CHARTS, PULSES, SNAPSHOTS and INSTRUCTIONS is explained later in this chapter.

Note:	When scheduling CHARTS, PULSES and SNAPSHOTS CellWorks refers to list items by their position in the list and not by their name.

INSTRUCTIONS are powerful tools to program many aspects of an individual experiment. Every parameter that can be set interactively in the Execution module or in the corresponding monitor menu bar (chapter 5.8) can also be preprogrammed by an INSTRUCTION. We recommend the user first learns the interactive settings before using INSTRUCTIONS. The following categories can be selected from the popup menu of the INSTRUCTION subeditor in the EXPERIMENT module (see below):

- **"NPI"** amplifier settings ("Amp Mode", "Gain" and "Filter" frequency)
- **"Refs"** voltage reference settings ("Reference Voltage", "Offset Voltage")
- **"File"** file preferences (e.g. "Write Pulse to File", "Write Instructions to File",...)
- **"Sweeps"** CHART and PULSE settings (e.g. "First sweep in Chart", number of "Sweeps in Chart",...)
- **"Timing"** timing settings (e.g. "Pulse Trigger Mode", "Wait" time to next command, ...)
- **"Chart Buffer I"** chart buffer handling (e.g. "Buffer size", "Data reduction", include "Pulse in chart", ...). Remember that these parameters concern only the monitor buffer
- **"Chart Buffer II"** time base for included pulses. Remember that this parameter concerns only the monitor buffer.
- **"Chart Monitor I"** Chart Monitor settings ("Mode", "X-axis" scaling, "Trace" selection)
- **"Chart Monitor II"** Chart Monitor settings (Monitor "Size", "Background" color, "Grid", "Display" settings)
- **"Pulse Buffer"** "Pulse buffer settings (similar to "Chart Buffer I and II")
- **"Pulse Monitor I, II"** Pulse monitor settings (data reduction or not)
- **"Till I, II"** settings for the Till monochromator (chapter 7.2) (e.g. "Wavelength", "Integration Time",...)
- **"Chart Monitor III"** further configuration of the X-axis in the Chart monitor
- **"Chart Monitor IV"** configuration of the Y-axis in the Chart monitor
- **"Chart Monitor V"** cursor handling in the Chart monitor
- **"Pulse Monitor III, IV, V"** Pulse monitor settings (similar to "Chart Monitor III, IV and V")
- **"Online I (from file)** Online module configuration settings. These Instructions are used to set module options by loading a configuration file. In the upper part of the window, the user selects an Online Module and the corresponding configuration file for loading. In the lower part of the window, the user selects the part(s) of the Online module (e.g. Options,

Export or Trace) to be configured according to the configuration file

- **"Online II (direct)** Online module settings ("Export" on/off, saving options, menu commands to be executed). These Instructions are used to set module options directely. Remember that CellWorks starts counting with zero.

Note:	The configuration file is loaded once and stored within CellWorks. If the user changes a configuration file that is used in an "Online I" – INSTRUCTION, this configuration file has to be reloaded into the INSTRUCTION in the EXPERIMENT editor. Otherwise the configuration is not updated.

INSTRUCTIONS which influence the execution of CHARTS, PULSES or SNAPSHOTS will be executed when the EXPERIMENT schedule list reaches the corresponding command line. The settings then become active for the remaining elements of the schedule list. The execution of CHARTS, PULSES or SNAPSHOTS does **not** wait for completion of INSTRUCTIONS which do **not** influence CHARTS, PULSES or SNAPSHOTS (e.g. monitor settings). We therefore recommend to include a "Wait" command (e.g. 1s) if you want an INSTRUCTION to be executed before the next PULSE or CHART starts.

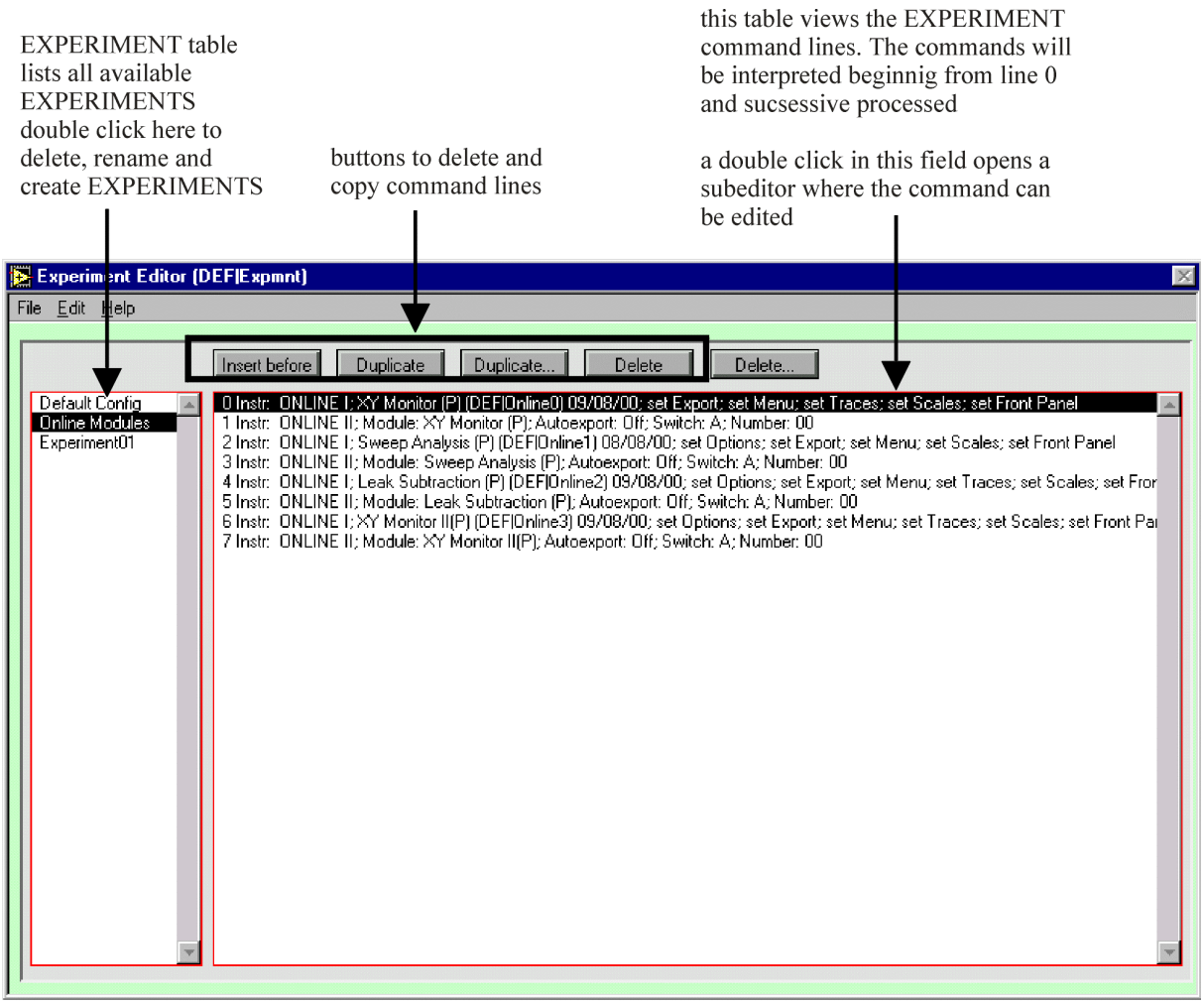


Figure 16: CW Experiment Editor

How to create a simple EXPERIMENT

- Open the CW Experiment Editor by the corresponding button in the CW Manager
- **Create a new EXPERIMENT**
  - Double click a name of an experiment in the EXPERIMENT list (left) to open the subeditor.
  - Click the button “Order Locked” if it appears red
  - Select an EXPERIMENT in the EXPERIMENT list (left) and click the button “Duplicate”.
  - Rename the duplicated EXPERIMENT in the small upper name editor field and move it to the desired location in the EXPERIMENT list.
  - OK the subeditor to close it.
- Select the new generated experiment.
- Similar to the CHART or PULSE editor it is possible to duplicate or delete command lines using the “Duplicate” and “Delete” buttons at the top of the window.

- **Modify a command line**
  - Double click the command line in the right editor field. The subeditor is opened.
  - Select a category (CHART, PULSE or SNAPSHOTS) in the upper pull down menu. If you release the mouse button all items of the category previously defined by the user are listed, e.g. all PULSE protocols.
  - Select one of the available protocols, e.g. for PULSE "Simple Ramp"
    or
  - select an INSTRUCTION. If you release the mouse button an instruction appears at the command line. Double click the instruction to open the subeditor where you can select one of the INSTRUCTION categories described earlier in this chapter. A window opens and you can set the parameters of the category e.g. for npi: "Amp Mode", "Gain" and "Filter".

Note: A command line can hold only one CHART, PULSE, SNAPSHOT or INSTRUCTION

- **Write recorded PULSE data to file (using an INSTRUCTION)**
  - Generate a new command line (with "Duplicate" button) at the desired experiment position.
  - Double click the new command line and select INSTRUCTIONS in the popup menu.
  - Double click the INSTRUCTION command line.
  - Select the command group "File" in the popup menu of the subeditor and set: "Write Pulse to File" to "yes" (Figure 17) and OK all subeditors. After passing this command line, the recorded data during a pulse protocol will be written to file.

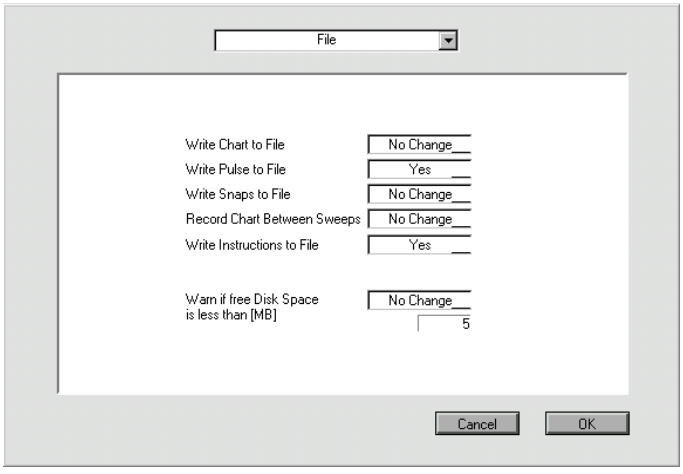


Figure 17: subeditor to edit the file INSTRUCTIONS

5.8. Execute CHARTS, PULSES and EXPERIMENTS, monitor data online and offline

This chapter describes how the preprogrammed CHART-, PULSE-, SNAPSHOT- and EXPERIMENT protocols are executed and how parameters like the amplifier gain setting or the values of the analog outputs can be set manually in the **CW Execution** module. Loading of data files in this module is explained in this chapter as well. The acquired data can be monitored in the **CW PULSE Monitor**, the **CW CHART Monitor** and in the **CW Online Modules.**

In contrast to all other modules and in order to display the acquired data immediately, the CW Chart Monitor, CW Pulse Monitor and CW Online modules can be active in parallel to the CW Execution module. Thus, we recommend opening CW Execution and at least one suitable monitor and/or Online module at the same time.

The upper part of the window contains the file information indicator field. “Rec#” shows the file record number. CW starts with record number “0” and it is possible to create or load other “day-files” by changing that number (see below). “Sample” is the short description (max. 16 characters) and the following number indicates the “Sample Identifier”, a number that can be used to organize the data. These file parameters can be changed in the “Exe Record” subeditor as shown in Figure 20.

Below the file information field are amplifier interface popup menus, where the user can read or define the desired amplifier settings "Amp Mode", "Gain" and lowpass "Filter". The values of "Sensed Gain" settings defined in the Hardware module (chapter 5.2) and linked to Ai in the Setup module (chapter 5.3), are displayed and can be set via the popup menu under certain conditions (see below).
Depending on the configuration of the CW Hardware module (Amplifier subeditor), these values can be read and/or controlled via digital- or telegraph lines or set manually. If CellWorks has been configured to read the amplifier settings, the corresponding popup menus appear in the window and actual settings of the amplifier are shown. But the settings can only be changed within CellWorks, if it is configured to control the amplifier (in the CW Hardware module). When the CW Hardware editor is configured to manually set these parameters, the menu first show “????”, but they can be set to other values. However, the same settings should also be made at the amplifier to get correct values for the acquired data.

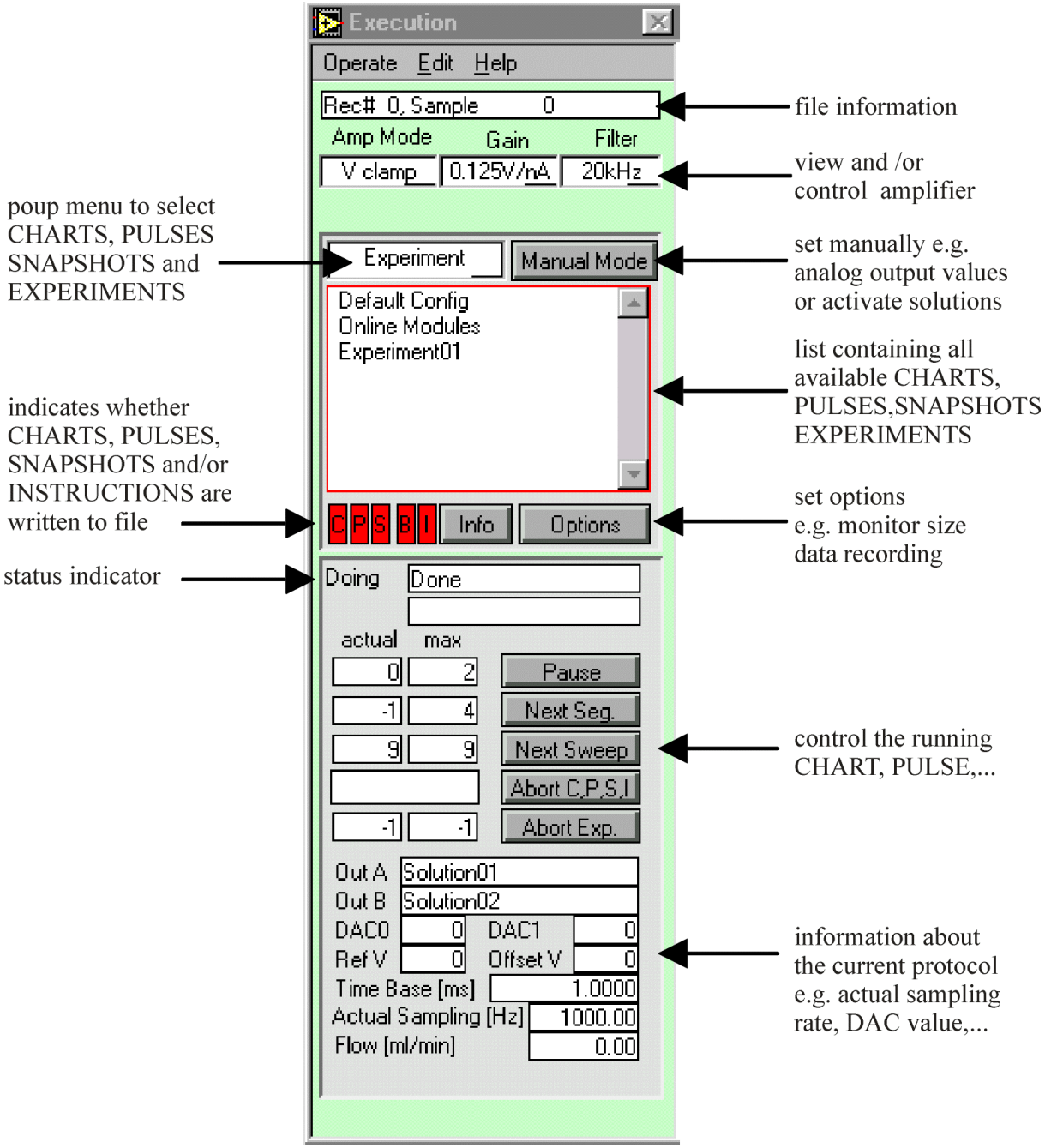


Figure 18: CW Execution module

Note: If analog telegraph lines are used, the values are read once before each chart or pulse starts and stored until the next pulse starts. That means changes of the gain position switch at the amplifier are not detected by CellWorks during a CHART or a PULSE.

The NPI bidirectional communication is active during a chart. The update period is 1s for slow CHARTS (CHARTS sampling below the user interface silencing limit frequency set in the Hardware module). The "Gain" value is written to file only once at the first segment of the CHART. That means if "Gain" is changed during a CHART the Ai values may be incorrect for 1s. The same is true for all other settings of the amplifier, i.e. "Amp Mode" and "Filter".

Therefore, we **strongly recommend** that you do not to change these settings during a CHART or PULSE, neither at the amplifier nor in CellWorks. If you want to change these settings via INSTRUCTIONS, be sure to add a "Wait" command for at least 1s.

The middle of the CW Execution window shows a list containing all predefined protocols of the selected category (you can select one of the categories CHART, PULSE, SNAPSHOTS or EXPERIMENT in the popup menu on top of the list). To execute a protocol, double click the corresponding name in the list. Execution begins immediately.
Below the list of available protocols, four status buttons indicate whether the executed CHART ("C"), PULSE ("P"), SNAPSHOT ("S") is written to file (button is red) or not (button is gray). The button "B" indicates whether data between two CHART sweeps are written to disk.
Click to the "Info" button to get detailed information (e.g. "Time Base", "Number of Sweeps", "Markers", "DAC" values,...) about the marked protocol in the list. Click the "Options" button to set several Options of execution, including management of recording to the hard disk (see next paragraph).

Options subeditor

Clicking to the "Options" button opens the Options subeditor which is divided into four subclasses of parameters, "General", "Chart Buffer", "Pulse Buffer" and "Till Photonic".

"General" subeditor

The "General" subeditor window is divided into three groups of parameters.

"**File**"

With the setting of the "File" parameters the user can specify, whether the recorded data are saved to disc. In addition, you can specify the amount of free disk space (in "Megabyte") at which CellWorks gives a warning to the experimenter when the recording is started

"**Trigger**"

With the setting of the "Trigger" parameters the user can specify whether CellWorks waits for trigger pulses to execute "CHART", "PULSE" or "SNAPSHOTS" experiments

"**Sweeps**"

The "Sweeps" parameters are related to the execution of "CHART"-, "PULSE"-and "SNAPSHOTS"-"Sweeps":

In most cases "Sweeps in Chart" or "Sweeps in Pulse" are set to "All", i.e. all "Sweeps" of this protocol are executed. However, the other settings of these parameters allow the user to skip certain "Sweeps" of "CHARTS" or "PULSES" or to execute them in a particular order. The settings for "PULSE" also applies to "SNAPSHOTS".

"Chart Buffer" subeditor

Clicking the "Chart Buffer" button opens the Chart Buffer subeditor. The button name changes to "Chart Monitor" indicating that the settings are related only to the chart monitor.

"**Buffer Size**"

sets the amount of Bytes for the Chart Buffer

"**Data reduction**"

sets the factor for data reduction, e.g. "5" means every fifth data point is shown on the chart monitor display

"**Reset**"

can be set to "avoid", i.e. buffer data are never cleared. Thus, if the "end" of the buffer size is reached, CellWorks starts at the beginning and overwrites existing data. The buffer data can also be deleted every "Chart" or every "Sweep"

"**Pulse**"

sets whether or not PULSE data are included in the chart monitor

"**Clear Buffer Data**"

immediately clears the CHART buffer and erases all traces on the CHART monitor

"**for included Pulses**"

if the user has decided to plot PULSE data in the chart monitor, the setting of this popup menu specifies the "Time base [ms] for Chart Buffer". "Time base [ms] for Chart Buffer" allows the user to force a "Point Interval" for the buffer, with "Point Interval" = "Time Base" * "Reduction" factor.

"Pulse Buffer" subeditor

Clicking to the "Pulse Buffer" button opens the Pulse Buffer subeditor. The button name changes to "Pulse Monitor" indicating that the settings are related only to the pulse monitor. In this subeditor the user sets the factor for data reduction of the pulse buffer, e.g. "5" means every fifth data point is shown on the pulse monitor display.

"Till Photonic" subeditor

If a T.I.L.L. Photonics Polychrom II monochromator and/or FDU ratiometric system is connected to CellWorks this subeditor is used to set various data acquisition parameters. See documentation supplied by T.I.L.L. Photonics for a detailed description.

Data storage conventions:

CellWorks creates for every user a DATA directory where recorded data are saved. For each day, a new subdirectory (folder) is created. The name of the subdirectory is composed of the user name (3 letters), the current year (2 or 4 numbers), the actual month (1 letter coded as "a" for January, "b" for February and so on (Note that "i" is not used)) and day (2 numbers). Each "daily" folder contains 4 files for each experiment. The first part of the filename is built by the same rules as the "daily folder".

- ❑ the "Nme" (name) file contains all the names of "Solutions", "Charts", "Pulses" etc.
- ❑ the "D" (data) file has accumulated all the data values of this experiment (the "E" in the filename stands for "Experiment" and the following two numbers are the number of this experiment, now called "record")
- ❑ the "F" (format) file links to the "D" file (to distinguish later the solitary recordings of the "D" (data) file) and more information, e.g. which Ao channels, time base, "Sweep" numbers etc. were used
- ❑ the "E" (Experiment) file is a leftover from an earlier CellWorks version (see also chapter 7.4)

Important: It is important to mention that ALL FOUR FILES are required for reloading (e.g. in CW Reader)! Thus, if you want to transfer data to another location, copy all four types of CW data files. Furthermore, there is only ONE "Nme" file per "daily folder" (i.e. per experiment day) and therefore this file-type should never be deleted manually (unless you want to delete the whole folder).

The status of execution as well as several parameter settings (i.e. digital outputs ("Out A" and "Out B"), "DAC" values, "Reference" and "Offset" voltages, "Time Base", "Actual Sampling" frequency) are monitored in the lower half of the window. To the left of the status fields are several buttons to influence execution. The user can "Pause" or abort execution of CHARTS, PULSES, SNAPSHOTS or INSTRUCTIONS ("Abort C, P, S, I") or abort the whole EXPERIMENT ("Abort Exp."). Furthermore, it is possible to skip the running segment or sweep and continue with the next ("Next Seg.", "Next Sweep").

Manual Mode

Sometimes it is necessary to change or adapt parameters of the experimental protocol due to unexpected behavior of the tissue, or simply to test the experimental configuration or tissue at the beginning of an experiment. Therefore, CellWorks has a "Manual Mode" of operation. Clicking this button opens the "Exe Manual Mode" window. Now the user can configure two groups of digital outputs ("Out A" and "Out B), set voltages at "DAC0" and/or "DAC1", define "Reference"- and "Offset" voltages, open or close valves and modify the flow rate of connected pumps. Furthermore, the user can select a PULSE protocol in the lower popup menu and execute this protocol repetitively by clicking the button "Do repetitive pulse". The button turns red and the pulses are executed until the "Do repetitive pulse" button is pushed again. To leave the manual mode, click "OK".

Note: The manual mode is very convenient to apply test pulses to the electrode or specimen!!

After execution has been started by double clicking the desired CHART, PULSE, SNAPSHOT or EXPERIMENT list item, the status of execution is shown in the "Doing" field, i.e. the CHART-, PULSE-, SNAPSHOTS- or EXPERIMENT-protocol that is currently

executed by CellWorks is displayed (see Figure 18). When performing an EXPERIMENT, the name of the EXPERIMENT is shown in the first row and the name of the currently executed protocol (e.g. “Simple jump”) is displayed in a second row. The two columns of numbers display the number of the currently executed segment, sweep or EXPERIMENT (left column) and the total number (right column). When execution is finished "Done" is displayed in the “Doing” field.

Further information on the status of execution as well as several parameter settings (i.e. digital outputs ("Out A" and "Out B"), “DAC” values, “Reference” and “Offset” voltages, "Time Base", "Actual Sampling" frequency) are monitored in the lower half of the window. To the left of the status fields are several buttons which influence execution. The user can “Pause” or abort execution of CHARTS, PULSES, SNAPSHOTS or INSTRUCTIONS (“Abort C, P, S, I”) or cancel the whole EXPERIMENT (“Abort Exp.”). Furthermore, it is possible to skip the running segment or sweep and continue with the next segment or sweep (“Next Seg.”, “Next Sweep”, see Figure 18).

During execution the acquired data are immediately displayed in the graphic field of the corresponding monitor module or in the selected Online module. CHART data are plotted in the CW Chart Monitor, whereas PULSE data can be displayed in the CW Pulse Monitor, CW Online modules and (with some limitations) in the CW Chart Monitor (in the latter case you have to set the PULSE popup menu in the Chart buffer subeditor of the Options menu to “include”).

Chart- and Pulse Monitor

The elements and menus are almost identical for both Chart- and Pulse Monitor. Therefore, we describe both modules in one chapter.

Note:	Many monitor settings can be preset by programming corresponding INSTRUCTIONS in the experiment editor (see chapter 5.7). It is a good idea to run a “configuration experiment” prior to experiments containing pulses, charts or snapshots, in order to have the correct configuration of the monitors.

The main part of the monitor modules is a large graphic field (monitor display), where the acquired data are displayed.

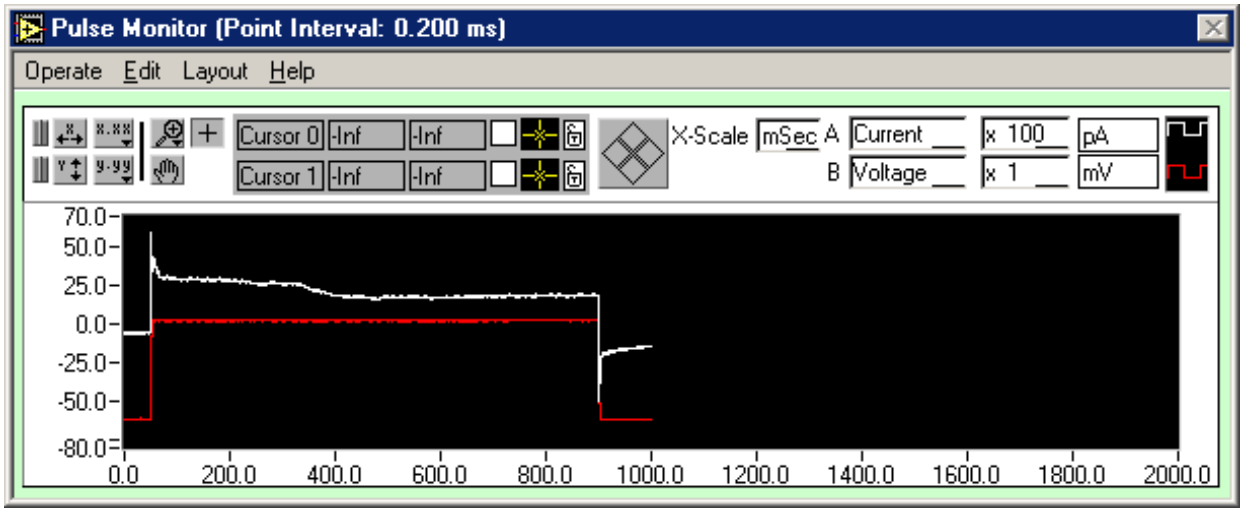


Figure 19: CW pulse monitor

The control fields in the upper right part of the window are used to configure basic monitoring parameters ("what is displayed"). The user can select two Ai channels (e.g. voltage and current), set magnification factors for each of the channels and set units and length of the X-axis. Clicking the field furthest to the right (with the trace icon) opens a pull down menu that allows the user to select graphical settings for each of the channels individually, e.g. line- and point style, color, interpolation mode, ...).

The control elements in the upper left corner set autoscaling (for X- and/or Y-axis) ON or OFF, specify the scale format, precision and mode and are used to activate zooming functions To change the scaling of a graph axis manually simply click the corresponding value, type in a new value and press <Return>.

The control elements in the upper middle part above the monitor display are used for the control of two crosshair cursors. After starting the monitor the cursors are not active. To activate them, click the first field labeled "-Inf" and type the X-value (e.g. 0). Then click the second "-Inf" field in the same row and type the Y-value (e.g. 0). The cursor appears at 0,0 in the monitor display. For the second cursor, perform the same procedure in the second row. The control elements marked with a crosshair and a padlock are used for further configuration of the cursor style and cursor behavior respectively. The cursors are moved by dragging or by using the right field of the cursor control elements.

The commands in the menu bars of CHART- and PULSE monitor are almost the same. There are some differences only in the "Operate" menu which will be described separately for CHART- and PULSE monitor.

"Edit" menu

standard windows menu for copying, cutting, pasting, ...

"Layout" menu

"Clear Cursors"	immediately removes the cursor(s) from the graph
"Background black / white"	sets the background to the corresponding color
"Don't show grid"	immediately removes the grid from the graph
" show grid"	shows a grid in the graph
"Size xxx"	sets the size of the monitor module window to xxx

"Operate" menu (Chart Monitor)

"Don't update"	"freezes" the monitor i.e. the monitor is not updated when CellWorks acquires further data
"Monitor"	the monitor is updated when new data are acquired
"Replay"	after setting the monitor mode to "Replay" it is possible to replay certain parts of the chart. For this purpose a "+" and a "-" button appears after the selection of "Replay" left to the popup menu. Clicking one of these buttons leads to the replay of the next or previous part of data on the monitor
"Printer Setup"	calls the standard Windows "printer setup" dialog
"Print Window"	calls the standard printer dialog to print the chart monitor window
"Close"	closes the chart monitor, but don't release it from memory
"Quit"	closes the chart monitor and releases it from memory

"Operate" menu (Pulse Monitor)

"Don't update"	"freezes" the monitor, i.e. the monitor is not updated when CellWorks acquires further data
"Monitor"	the monitor is updated when new data are acquired
"Marker 1"	the monitor shows only the part of the pulse defined by Marker 1 (see CW Pulse Editor, chapter 5.6)
"Marker 2"	the monitor shows only the part of the pulse defined by Marker 2 (see CW Pulse Editor, chapter 5.6)
	if the monitor is configured to show "Markers" the user can define the time for "t0" at the display
"t0=0	the beginning of the marked part of the pulse is set to "0", e.g. the shown trace begins at "0 ms" even if the marker is set to for instance segment 5 that begins at t=100 ms in the pulse protocol
"t0=real"	the beginning of the marked part of the pulse leaves untouched, e.g. the shown trace begins at "100 ms" if the marker is set to segment 5 that begins at t=100 ms in the pulse protocol
"Full Pulse"	the monitor shows the whole pulse
"Printer Setup"	calls the standard Windows "printer setup" dialog
"Print Window"	calls the standard printer dialog to print the pulse monitor window
"Close"	closes the pulse monitor, but doesn't release it from memory
"Quit"	closes the pulse monitor and releases it from memory

Note: The printing feature of CW is for an overview only. It is not intended to be used for publications etc. For data processing and printing please export data to an appropriate program like IGOR, Sigma Plot etc.

The Exe Record subeditor for file management

"Record File" located in the Execution menu "Operate" opens the Exe Record window, where the user can perform several file related actions, e.g. edit the actual recording list, load already recorded data files, create new recording files and edit the file parameters displayed in the upper part of the Execution module (file information).

In the default configuration one part of the Exe Record window is hidden. It can be shown by pressing <Ctrl+Shift+D> or selecting "Toggle Size" in the "Display" menu of the menu bar. In the following we assume the Exe Record window to be fully displayed (see Figure 20).

In the upper left part of the window the actual recording list is displayed. Above the list the "owner" of the list is shown, i.e. "User today" for the actual experimenter or – if a previously recorded data file is loaded – the name of that file. Further, there is a field "Record number" and a box containing a number that can be changed. Initially the box contains "0" which means that all CHARTS, PULSES or SNAPSHOTS are saved in the "D" and "F" files with "E00.D"and "E00.F" respectively. If the user increments the number in the box to "1" the following protocols are saved as "E01.D" and "E01.F" respectively (see "data storage conventions" earlier in this chapter and chapter 7.4).

Note:	Only CHARTS, PULSES or SNAPSHOTS that are saved to disk are listed in the recording list.

To replay a CHART, PULSE or SNAPSHOT simply double click the corresponding name in the list. The protocols are replayed in the corresponding monitors, i.e. CHART-, PULSE- or Online monitor.
Click to the corresponding button below the recording list, in order to delete the last entry from the data file.

The lower left part of the "Exe Records" window shows the execution parameters and is identical to the corresponding part in the "Execute" window.

In the right part of the "Exe Records" window the user can increment the "Sample Identifier" of the current record, give a short (max. 16 letters) "Description" that is display beneath the "Rec#" in the "Execute" window and give "Comments" (max. 160 letters) to the current record. If the this part is no longer used it can be closed by pressing <Ctrl+Shift+D> again.

"Timing" menu

The "Timing" menu of the menu bar contains several commands to set the speed of replay of CHARTS and PULSES. For CHARTS the user can set display speed factors and for PULSES the interval time between single sweeps. A delay can be set for instructions to ensure execution immediately.

"File" Menu

The "File" menu contains some commands for loading recorded data into the Exe Record subeditor. The name of the loaded file is shown at the top of the right part of the Exe Record window. "User Today" and "Selected Folder" lets the user toggle between the records of the

current user today and the file loaded via “Load Data” command. “Printer Setup” and “Print Window” call the standard windows dialog boxes.

To leave the Exe Record window and go back to the Execution window simply click to the “OK” button at the bottom of the window.

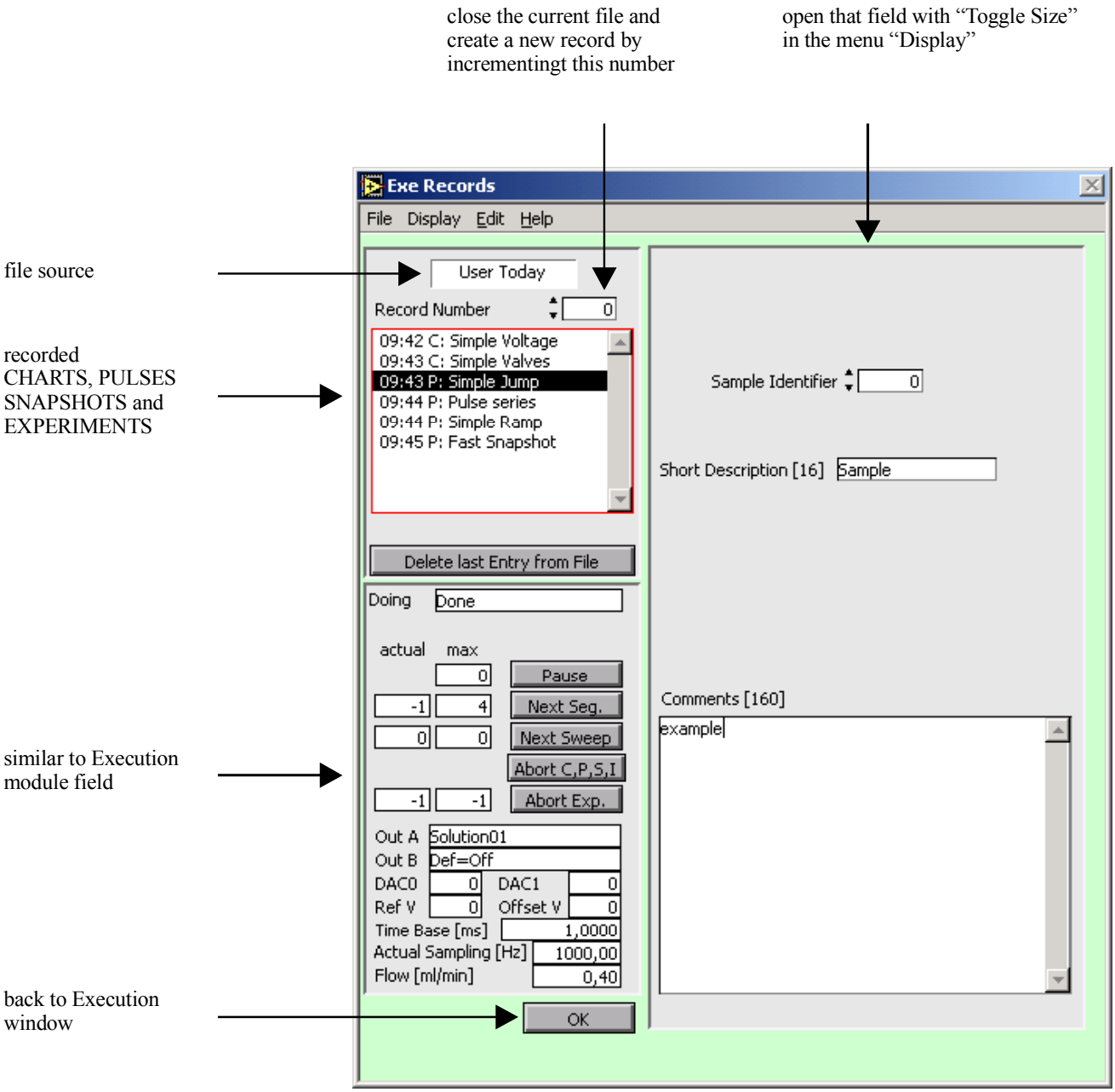


Figure 20: Exe Record window

In the following we give some examples of how to operate the Execution module.

Start a PULSE in the CW Execution module

First test whether the analog inputs and outputs work properly.

- Connect the analog input 0 (Ai0) to the analog output 0 (Ao0) and the analog input 1 (Ai1) to the analog output 1 (Ao1) at the front panel of the breakout box with BNC cables. If you have a TEC-03X-CW amplifier with the optional integrated I/O unit connect Ao1 with Ai2 at the rear panel of the amplifier (make sure that input channels Ai0 and Ai2 are configured in the Hardware module).

Note: In TEC-03X-CW Ao0 is already connected internally to Ai0.

- Start the CW Execution module with the corresponding button in the CW Manager and open the Chart- and the Pulse Monitor.
- If you use a TEC-03X-CW amplifier select the analog input 2 as trace "B" in the Pulse– and Chart Monitor.
- Select "Pulse" in the popup menu of the Execution module and double click "Simple Ramp".

A triangle-pulse with increasing amplitude for each sweep (trace A: corresponding to Ai0) and a square-pulse (trace B: corresponding to Ai1 or Ai2 for TEC-03X-CW , respectively) should be displayed in the Pulse Monitor (Figure 21). In the Chart Monitor you should see all sweeps.

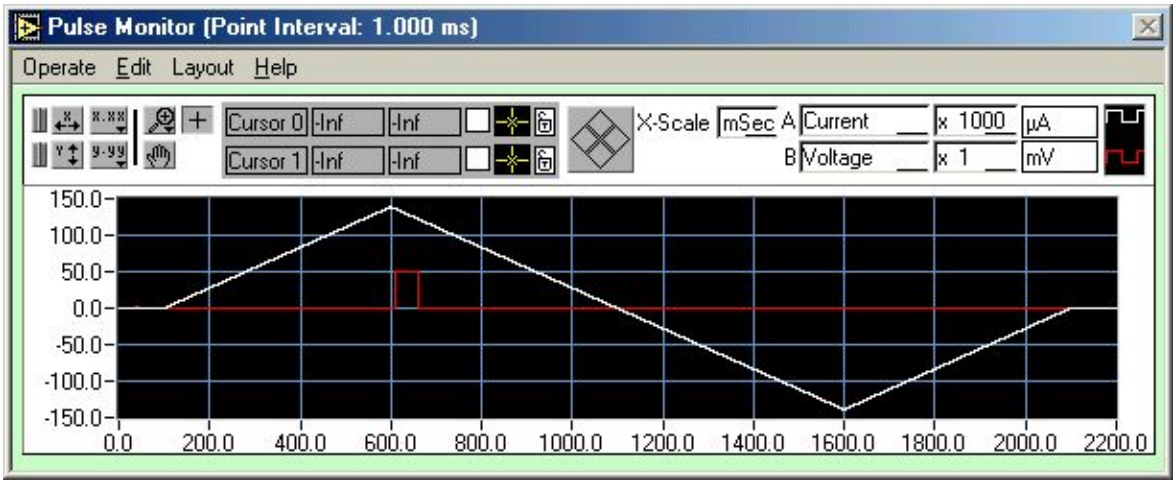


Figure 21: Pulse Monitor with the default PULSE protocol "Simple Ramp"

Important: If you have configured the scaling of Ai0 to show µA in TEC or nA in SEC amplifiers (Gain factor 0.001 in Setup Module) set the magnification factors for Channel0 (Current) to 1000 in order to see the signal!!

If you are successful, i.e. if your pulse monitor looks like Figure 21, connect your amplifier to the breakout box and the cell model and test the pulse protocol again.

Note: It's a good idea first to run a configuration EXPERIMENT that sets up the execution environment (to get familiar with the configuration of the execution environment try the settings of these parameters in the "Options" subeditor of the CW Execution module).

Open and close the current record file

- Open the Execution module and select "Record File" in the menu "Operate". The Exe Record window opens.
- Increment the "Record Number". CellWorks creates a new record file with index 01 or loads this file (if this file is already created). The maximum "Record Number" is 99, that means a limit of 100 files a day (per user).
- Decrement the "Record Number" to load an existing file with a lower index.

Load recorded data files and replay CHARTS, PULSES, SNAPSHOTS and EXPERIMENTS

- Go to the "Operate" menu in the Execution Module and select "Record File". The Exe Record subeditor opens.
- Select "Load Data" in the "File" menu and open the desired data file (be sure that the data file is not write protected. That is for instance the case if you try to read data files from CD).
- All CHARTS, PULSES, SNAPSHOTS and EXPERIMENTS stored in this file are displayed in the recording list. To replay an item double click the desired protocol.

The stored data will be displayed in the appropriate monitors and/or Online modules. The speed of the CHART replay can be set in the menu bar group "Timing". The INSTRUCTIONS in an EXPERIMENT would be repeated as well if they have been written to file.

Note: Because Online Modules can be active during replay it is possible to create and execute new data analysis procedures, e.g. I/V curves if one recognizes that the first online analysis was not appropriate.

5.9. Online analysis and data export with the Online modules

This chapter describes the selection and the use of Online modules for online analysis and PULSE data export. These Online modules can be used only for PULSE data, but not for CHART data.

While the CW Chart Monitor and CW Pulse Monitors just plot the recorded data, the CW Online modules can be used to perform some data analysis. The current CellWorks version has four built-in Online modules:

- Online Sweep Analysis (P)
- Online X/Y Monitor (P)
- Online XY Monitor II (P)
- Online Leak Subtraction

How to select an Online modules

- Open the CW User module with the corresponding button in the CW Manager.
- Select “Online Modules” in the popup menu (left).
- Select one of the four Online modules in the list and close the User module.
- The selected Online module is now available and can be launched with the “Online A” button in the CW Manager.
- Start the Execution- and the Online module and activate a PULSE protocol to see how the Online modules work.

Online Sweep Analysis (P)

This module is the most used in CellWorks. It is supplied to show and analyze data to get a quick survey of the running experiment.
The acquired data of up to sixteen Ai channels are plotted online in the large upper left graphic field of the Online Sweep Analysis module (Figure 23). This is the “Online” monitor that contains four cursors as well. The other four graphs are “Analysis” monitors, that display the results of various calculations which are performed with the data points measured by the four cursors of the “Online” monitor (see below).

The submenu “Options” in the “File” menu is used to determine how data are displayed and what kind of calculation is performed in the analyze windows. It contains the following fields (see Figure 22):

- “**Graph 0**”. Here the user can select which data are displayed on the “Online” monitor (i.e. which Ai channels and which part (full pulse or markers) of the sweep should be monitored) and how they are displayed (e.g. color, interpolation style, history ...)
- “**Layout**” sets which analyze graphs are displayed and at which positions and in which size they occur
- “**Cursor Windows**”. Here the user decides which data are taken for calculations in the “Analysis” monitors. The cursors are counted from 0 to 3 and are referred in the Graph 1-4 fields as V0 to V3. For each cursor two parameters are available to define a “Cursor Window”: a popup menu with “+/-“, “+” and “-“ items and a value field, which gives the delta X-range of the “Cursor Window”. The items in the popup menu give the “direction” relative to the cursor position. The default setting is “+/-“ and “10”, which means that – if “Units” are set to “mSec” – the delta X-range of the “Cursor Window” is 20 ms wide. “Derived Values”: This popup menu has the items “min” (minimum), “max” (maximum), “mean”, “peak over baseline” and “valley under baseline” and is related to the “Cursor Window”, i.e. its setting defines whether CellWorks searches within the “Cursor Window” for the lowest or highest value or calculates the mean of the data in the “Cursor Window”.
  For “peak over/valley under baseline ” first the baseline is calculated from the first and

last 10% of the cursor window by fitting a mean line to the data. Then this baseline is subtracted from the original data and maximum (peak) or minimum (valley) are determined.
The result of this search or calculation is called “Derived Value” and can be used for further calculations.

- “**Graph 1**”, “**Graph 2**” are used to show time-based diagrams. In the easiest case just the time course of the data calculated in the “Cursor Window(s)”, the “Derived Value(s)”, are shown. “Value A” is determined by two settings: first, “V0” to “V3” (which Cursor should collect the data) and second, the Ai “channel” (which analog input line should provide the data). Additionally, the user can perform further calculations with a second value (“Value B”) which is determined analog to “Value A” and display this result in the graph. As operators “+”, “-“, “*”,”/” and “1/Value A” are selectable. The other parameters are used to format the display.
- “**Graph 3**”. This is the “histogram”-graph to plot the specified type of cursor measurement as bars at the graph. The user can define a “value-range” and divide the range into a certain number of sections (CellWorks calls these sections “Bins”). The result of the calculation is a distribution histogram.
- “**Graph 4**” is the x/y-display where “Value A” is plotted against “Value B”. Like in the other analyze windows the user can set interpolation mode and point style as well as the Y-axis mode (Decimal, Scientific or Engineering labeling and number of digits after the decimal point). In addition the mode of the X-axis can be configured.

Note: Most changes are only displayed correctly when the next pulse is executed.

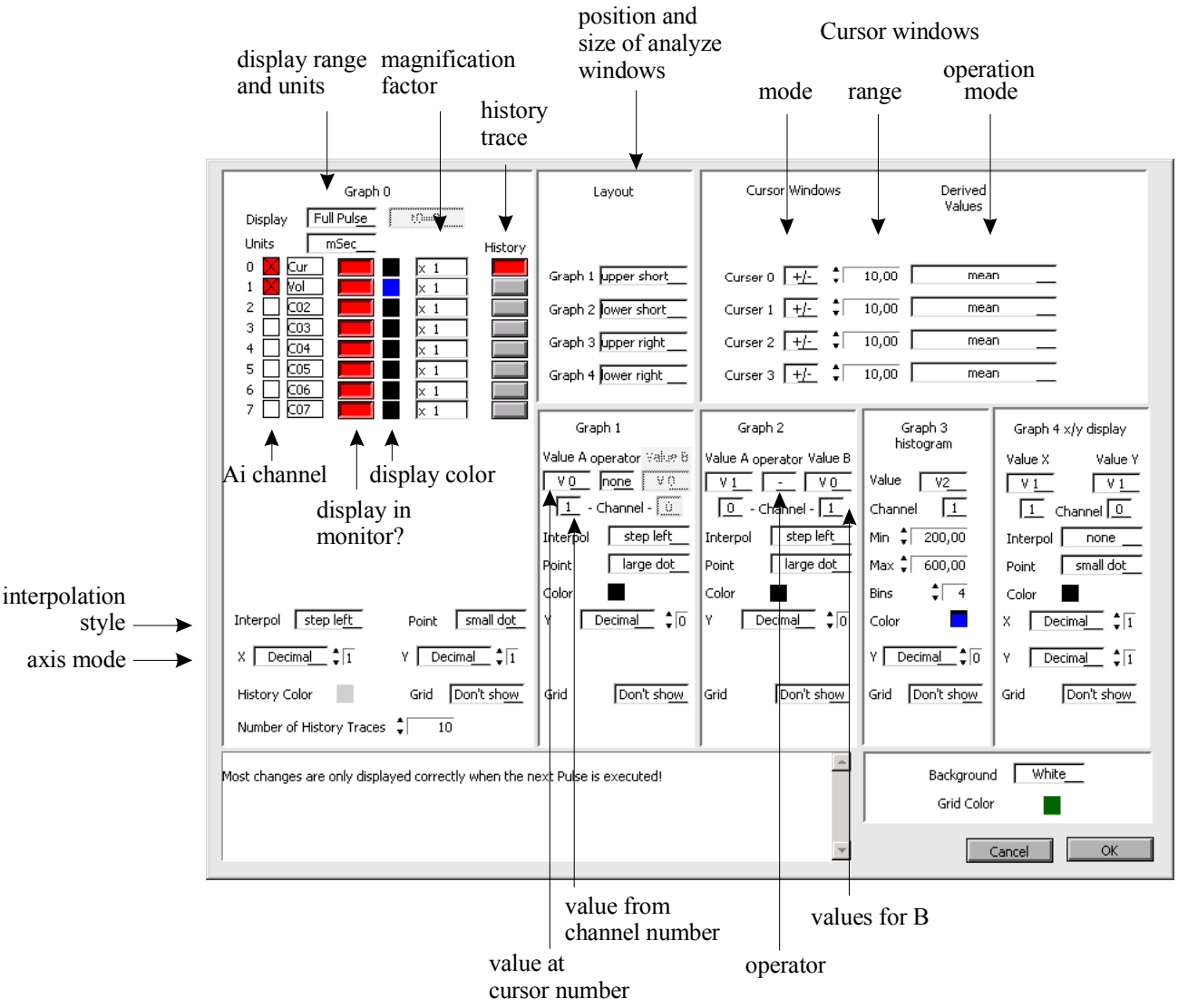


Figure 22: Online Sweep Analysis (P) “Options” window

To change the X- or Y-scaling of the graphs manually click to the highest or lowest scaling value, change the value via the keyboard and either press <Return> or click with the mouse to any other point outside the graph (but within the module window). For both graph axes, there is an auto-scale function available as well. It is accessible in the “Cursor-display and scaling” field (right to the “Online” monitor). A click to the two “auto-scale graph”-buttons automatically scales the corresponding axis of the “online” graph, so that all of the recorded data are visible with an appropriate magnification.

While the sweeps of a PULSE experiment are executed and the sweep data are plotted at the upper “Online” graph, the cursor calculations are performed online for each sweep and the four lower analyze graphs are updated immediately, while the calculated data of the former sweep are still kept. Thus, it is possible to visualize various changes of the recorded voltage or current responses that occur from sweep to sweep and to perform simple operations, e.g. to calculate an I/V curve in “Graph 4”.

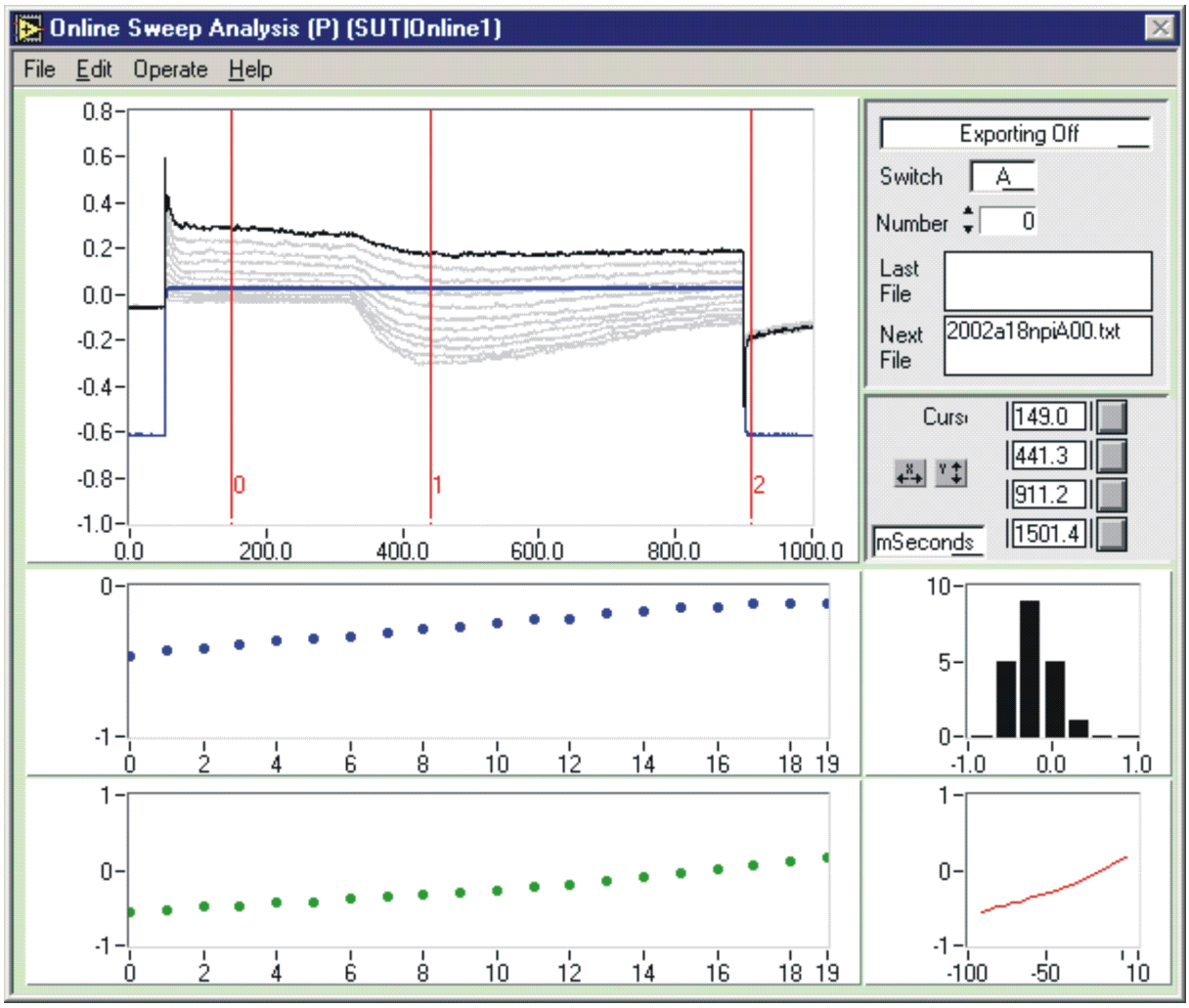


Figure 23: Online Sweep Analysis (P) window

Graph 0 shows the pulse protocol (Ai0 black, with history (gray) on, Ai1 (blue)). The protocol consists of 10 sweeps incrementing one channel (Ai1). Graph 1 tracks Ai0 at Cursor 0, Graph 2 shows the voltage of Ai1 at cursor 1. Graph 3 plots a histogram of Ai0 (Min: 0, Max: 4, Bins 5) and Graph 4 shows a X-Y Graph with X=Ai1 and Y=Ai0. Note that the export function is set to "OFF". If set to "ON", the filename will be created with the default options in "Export settings" (see field "Next File").

The "File" menu of the menu bar offers commands to handle the configuration file of the Online module ("Load", "Save", "Delete", ...), to configure the module ("Options" (see above), "Export settings" (see below)), to call the standard windows printing dialog and to "Close" or "Quit" the module. If the user wants to save axes scaling as well, he first has to create new default settings (see below) with the new axes scaling and then save the configuration file.
The "Operate" menu contains commands to set the operation mode ("Don't update" and "Monitor"; see also PULSE- and CHART Monitors) and to set autoscaling for the analyze windows. In addition, there are two commands concerning the preferences ("Reset to Preferences" and, to create new default settings "Make current settings new Preferences").

Data export

Using the export functions all recorded data and also the calculated data can be saved to a file on the hard disk. Various export preferences can be set by selecting "Export Settings" in the "File" menu. To turn ON the automatic export function, click to the popup menu "Exporting" on the top right of the "Online Sweep Analysis (P)" window (Figure 23). The names of the export files are built automatically by CellWorks according to the settings of "Switch", "Number" and various parameters of "Export Settings" (Figure 24). Selecting "Export Settings" in the "File" menu opens a window with several parameters and settings:

- data **"Export Format"** field with the format setting popup menu. Here the user selects whether to export the data in ASCII rows or columns, Igor text, Autes or Axon binary format

Note:	When you open "Export Settings" for the first time be sure to set the "Export Format" from "None" to the desired format. Otherwise no data will be exported even if the automatic export function in "Online Sweep Analysis (P)" window is turned on.

- **"Export Channels**" field includes the information which available analog input channels are exported to file
- **"File Name"** field (Figure 25 and chapter 7.4). Here, the user can set file name preferences, e.g. whether the name includes the date, set suffix or prefix letters or numbers and whether one file per PULSE or one file per PULSE sweep is written to hard disk

Note:	If you want to set a file extension via the field "Suffix", be sure to include a ".", e.g. ".txt" for Ascii columns for import in Excel.

- **"Data Header"** sets header information within the data file
- **"Data Names"** in this field the user can decide whether the data names should include the date, the channel information, time,...

The fields "Data Header" and "Data names" are normally used to organize the data within the file to facilitate automatic analysis.

- **"Data"** field to select which data are exported. The user can select the data range (Full Pulse or Markers (see chapter 5.6 how to set markers)), the data format ("Exponential" or "Floating Point") and the precision. Furthermore, it is possible to exclude data from exporting. Set raw data to "Export raw Data" and calculated data to "Don't export calc data" if you want to export only the raw data. Set the parameters the other way around to export only data that are calculated in the analyze windows.

Figure 26 illustrates the structure of the resulting Ascii-file using the settings in Figure 24. "A" shows the beginning of the file, "B" shows the end of the first sweep and the beginning of the second sweep, and "C" shows the end of the file with the calculated data and Notes.

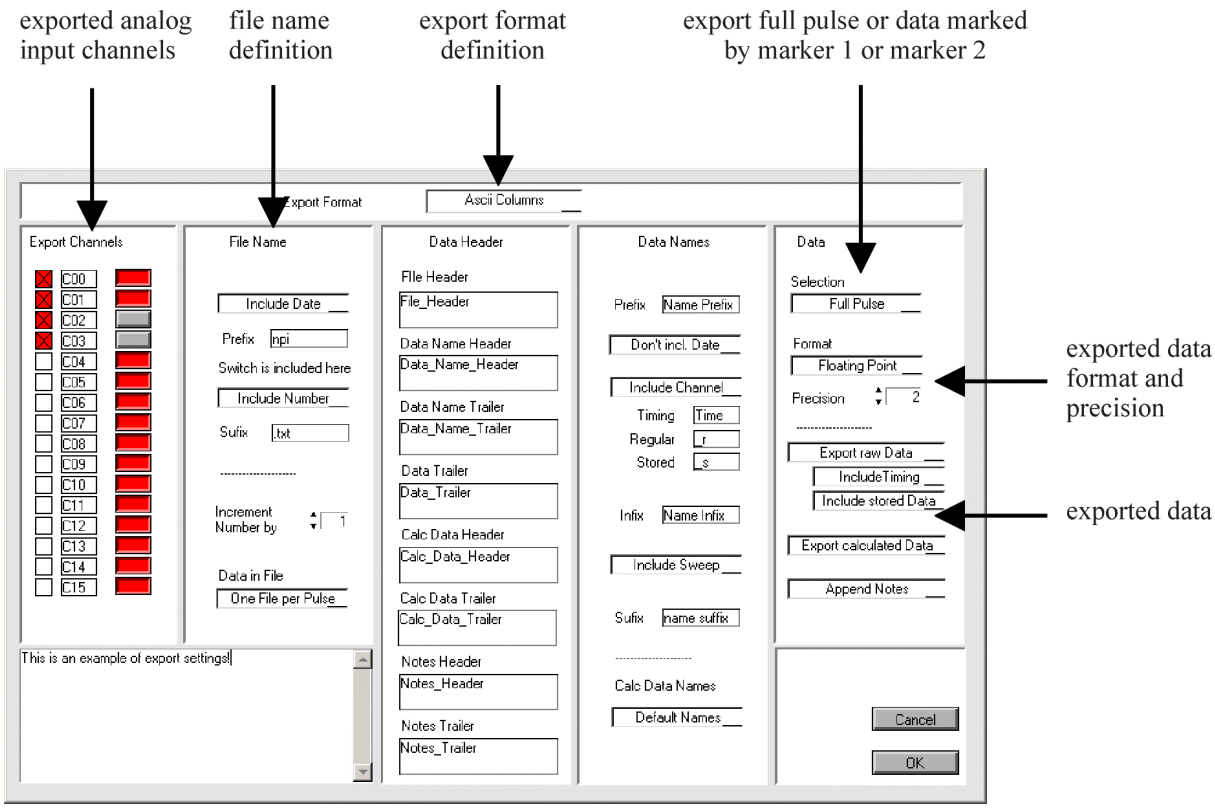


Figure 24: export configuration window

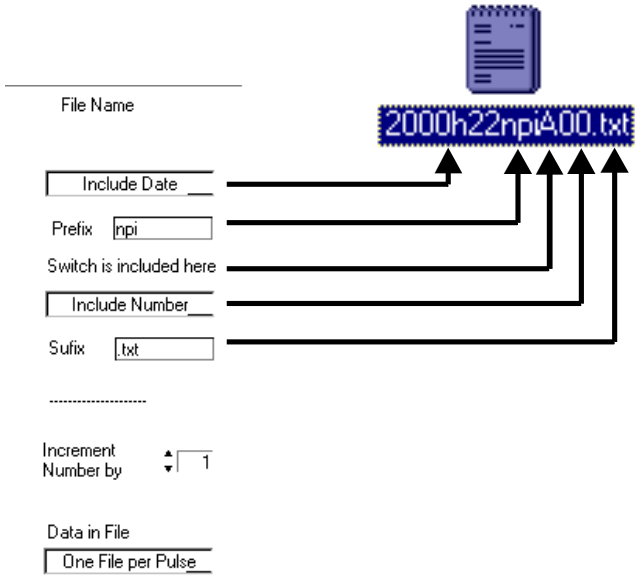


Figure 25: file names
translation of settings in the “File Name” field of the export settings window into filenames

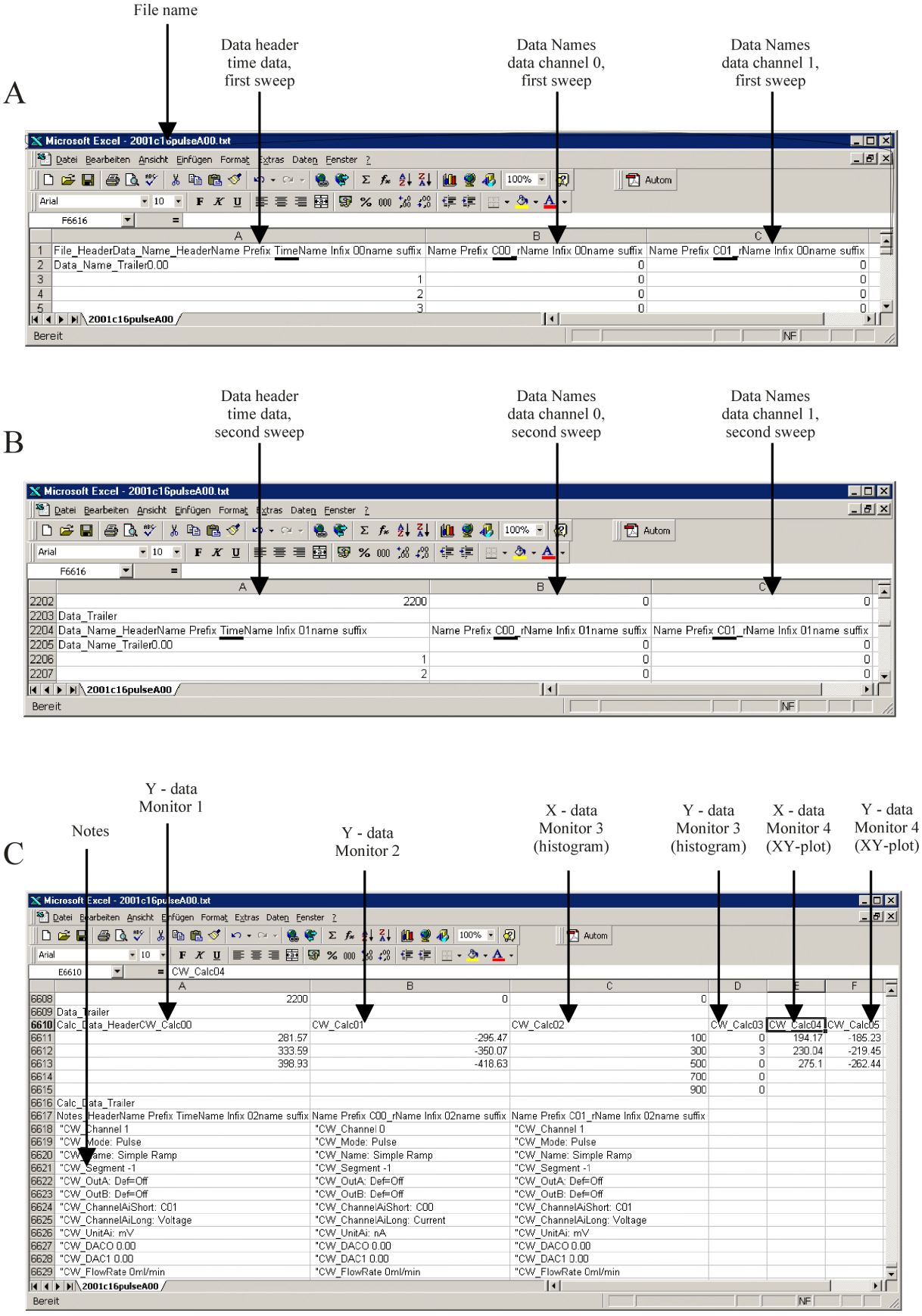


Figure 26: structure of an Ascii export file

Ascii export format

The Ascii export file is structured as follows. First, the raw data are listed.
The first column contains the time information and the other columns contain the data of the exported analog input channels i.e. Ai1, Ai2....
If set so in the export configuration window the first row in the first column contains the File Header. The first row in the following columns contain the Data Names and the Ai channel numbers, i.e. C00, C01....
The second row in the first column contains the Data Name Trailer and the first time data point. In the second row of the following columns are the analog input data. The other rows contain the time and Ai channel data respectively.
Sweeps of the PULSE are separated by the Data Trailer and Data Names of every single sweep.
Second, the calculated data are listed. The data of the four monitors are saved in six columns. Columns 1 and 2 ("CW_Calc00" and "CW_Calc01") contain the Y-data of monitor 1 and 2 which produce one value per sweep. The X axis (sweep number) is not saved in a column. The data of Monitors 3 (histogram) and 4 (XY-plot) are listed in the following 4 columns. The column labeled "CW_Calc02" contains the X-data and the column labeled "CW_Calc03" contains the Y-data of the histogram. "CW_Calc04" and "CW_Calc05" contain the X- and Y data of the XY-plot monitor respectively.
The last part of the file contains the Notes with some information about the data and the experiment e.g. pulse name, data acquisition rate, solutions, Ai channel names...

Note:	CellWorks uses a dot as decimal point whereas most of the internationalized programs use a comma and after importing the Ascii file these programs might interpret numbers as text. Thus, be sure that the program will recognize a point as decimal point.

An example of the various "Export Settings" as shown in Figure 24 is supplied in the CellWorks Demo folder (CWE Default Demo\CONFIG). To test these settings the user can load the Online module configuration file "Online Export Settings Demo" using the "Load" command in the "File" menu.

Online XY Monitor (P)

This module is used (1) to monitor ONE Ai channel over time or data points respectively or (2) to show the data by plotting one Ai channel against the other. Furthermore, the user can export the data with the export function.

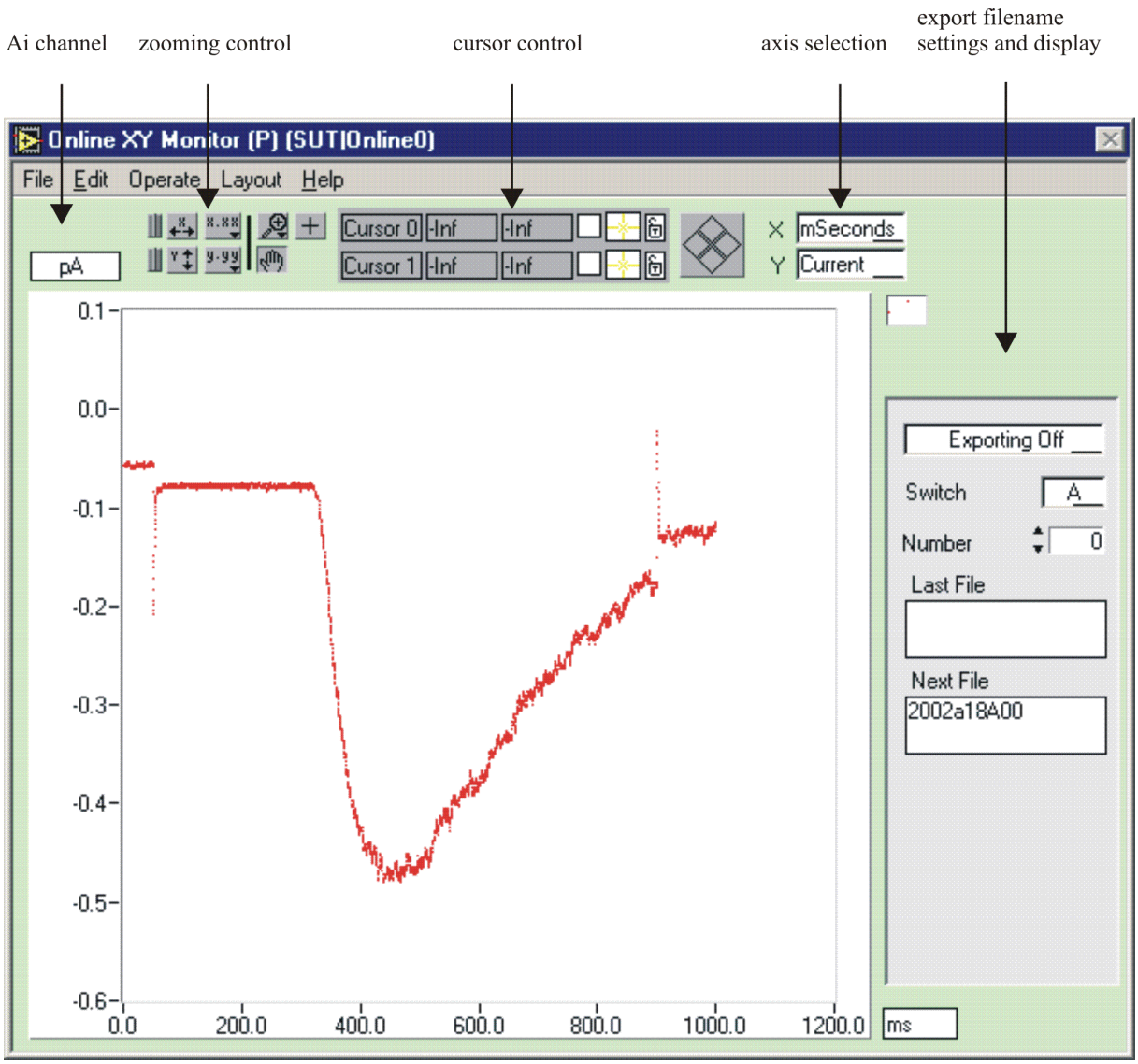


Figure 27: the Online XY Monitor (P)

If the user has selected “Online XY Monitor (P)” in the “user module” a click to the “Online” button in the CW Manager opens the “Online XY Monitor (P)” window (Figure 27). The window looks similar to the “Pulse Monitor” and several functions and menu commands are the same. On the top of the window the user finds elements for zooming and cursor control (as in the “Pulse Monitor”, see chapter 5.8) and on the right settings for export (as in “Online Sweep Analysis (P)” (see above).
The big difference from the “Pulse Monitor” is that the user can select for both axis an analog input channel by clicking to the pull down menu top left (Figure 27).

The “File” menu contains the same commands (except “Options) as in the “Online Sweep Analysis (P)” module (see earlier in this chapter). “Operate” and “Layout” menu are the same as in the “Pulse Monitor” module (see chapter 5.8).

Online XY Monitor II(P)

The Online XY Monitor II(P) expands the Online XY Monitor (P) so that several storing functions are added. All menus and functions are the same except some commands in the “Operate” menu and the pull down menus top right of the window (in this manual called *display options*). In the “File” menu an “Option” command is added where the user can select the Ai channels for storage operations.

Display options. There are two pull down menus (each for one trace) with several options to select what is displayed.

“Data”	the raw data are monitored
“Stored”	the stored data are displayed. In the “Operate” menu the user sets which data are stored
“Data - Stored”	the stored data are subtracted from the current data and the result is shown
“Data + Stored”	the stored data are added to the current data and the result is shown

“Operate menu”

“Store 1st sweep”	the first sweep of a protocol is stored
“Store Sum of Sweeps”	sweep by sweep the data are added up and the actual sum is stored
“Store Mean of Sweeps”	sweep by sweep the data are added up and the actual mean is stored

Online Leak Subtraction (P)

The “Online Leak Subtraction (P)” module is similar to the Online XY Monitor II(P) and is programmed to perform a simple leak-subtraction of the current data. The idea is to run an experiment to get and store the actual leak data. Afterwards the user can display the “raw” current data and the data that are subtracted by the stored leak current.

Note: In this module it is not possible to plot one Ai channel against the other.

6. Reading, Monitoring and Exporting Data with the CW Reader Program

The next chapter shortly describes how to load CellWorks data files into the **CellWorks Reader** program, how to monitor single sweeps of CHARTS and PULSES and how to export files or parts of files in ASCII or Igor format. A more detailed description can be found in CW Manual 4.0.

Offline analysis and export of CW CHART data is not possible with the modules explained in chapter 5. For this purpose you have to use the stand-alone application "CW Reader" (Figure 28), which is part of the CW program package. After starting the CW Reader the user can load (read) data files, which were saved during a CellWorks CHART, PULSE, SNAPSHOT or EXPERIMENT.

Note: CW Reader cannot load data files in ASCII- or Igor format.

Basically, the CW Reader follows the same concept of the user-interface as the modules of CW itself, i.e. window manipulations and selection of options are performed in the same way as in CellWorks.

To load CW Data click the "New Record" button in the upper left corner of the CW Reader window. A file menu appears where the data files can be selected for loading. After loading the file all sweeps of the recorded data are displayed on the left side. Select a sweep by clicking it. Select and superimpose several sweeps by clicking while holding down the "Shift key".

Various display and scaling parameters are available in the middle area above the monitor field (Figure 28). Many of these parameters follow the standard display and cursor control elements of CellWorks. The two columns of text fields in the upper right area of the CW Reader window display the solutions which were applied at "Out A" (left column) or "Out B" (right column).

To export data, first click the "Settings" button to open the "CWR Settings" window. In the lower left field of the window called "Export" you can set the export parameters according to your needs (Figure 29). Close the window with "OK" and click the "Export" button at the top of the CW Reader window. You are prompted to enter a filename. Do so and click the "Save" button. By default all data that are displayed are exported to that file.

Note: File extensions were **not** automatically generated.

In the "CWR Settings" window the user can - beside changing export parameters – set several display parameters for CHARTS and PULSES (e.g. display color and style, interpolation ....), set the option to include information in the printout and save or load settings from disk.
To format the display first decide in the upper left field "Styles" where the defined style should come from ("Default A" or "B", "By channel", "By segment" or "By sweep"). The selection possibilities in the pull down menus refer to the fields on the right (Figure 29). These are configured by clicking in the field to open a pull down menu with several format options.

Note:	The "Prefs" button in the CWR main window does not function in this version.

Note:	The current version 3.6 differs only slightly from version 3.5 which is described in more detail in the CW 4.0 manual.

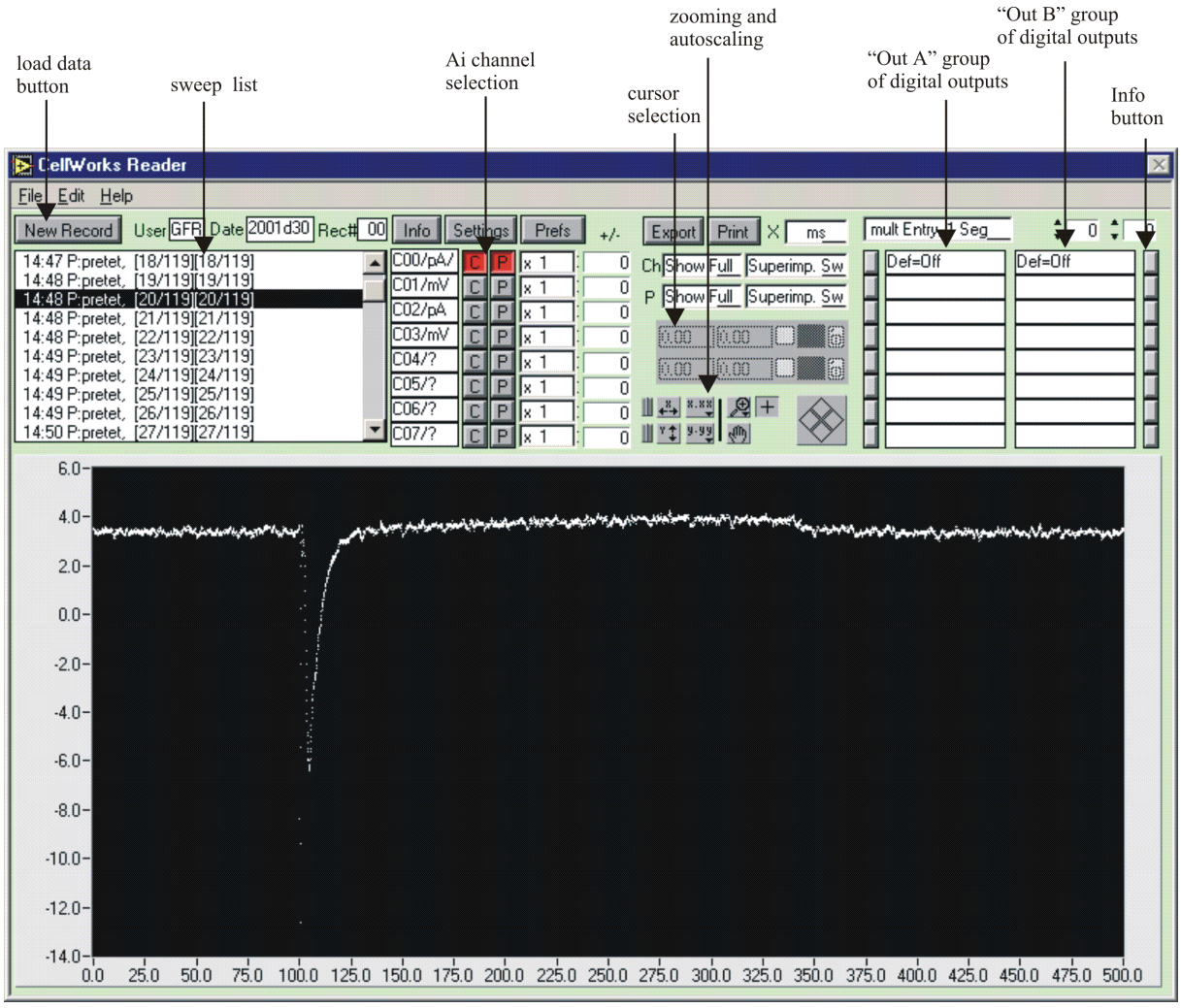


Figure 28: CW Reader window

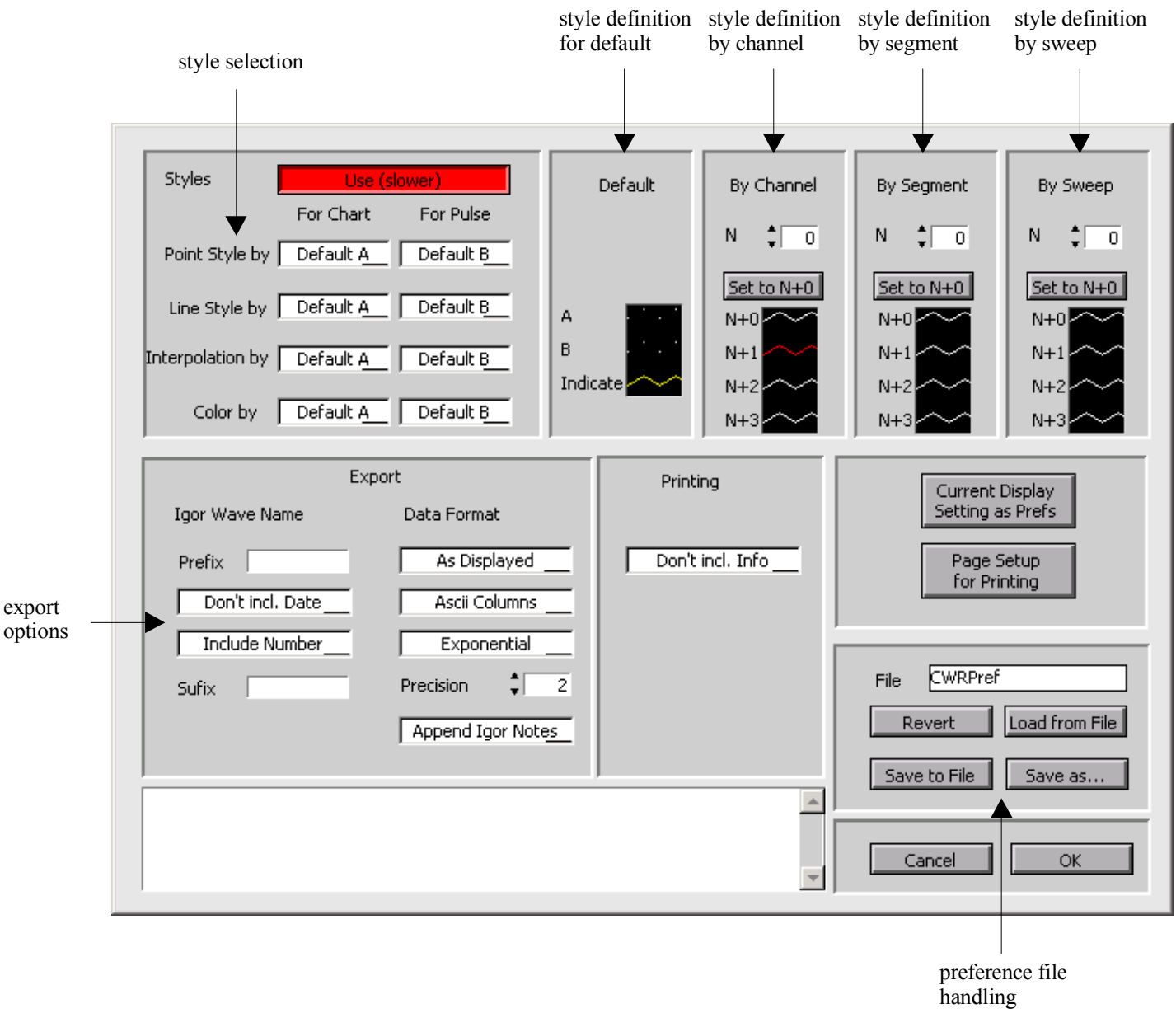


Figure 29: CW Reader settings window

7. Appendix

7.1. Specifications

For low cost E-series boards

analog input	
Number of channels in single ended mode	maximal 16
Number of channels in differential mode	maximal 8
input resistance	1MΩ (with breakout box INT-20X)
max. input range bipolar	±10V, ±5V, ±1V (software selectable)
max. input range unipolar	0..10V
number of channels, transfer characteristics and resolution depend on the board that is used. Please read the appropriate user manual from National Instruments (shipped with the board).	
analog output	
number of channels	2
voltage range	±10V
transfer characteristics and resolution depend on the board type which is used. Please read the appropriate user manual from National Instruments (shipped with the board).	
digital output	
number of lines	up to 96 digital output lines (grouped as ports of 8 lines)

More information and specifications can be found at the National Instruments homepage (www.ni.com).

7.2. Additional hardware components

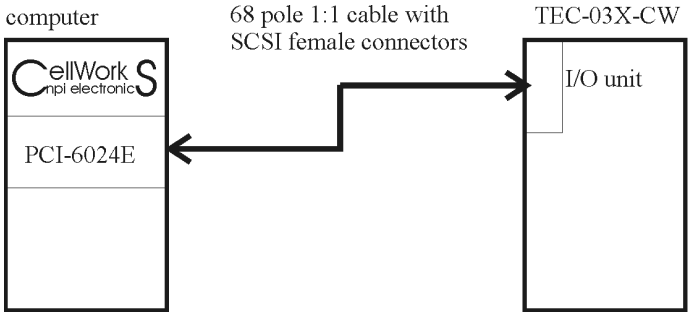
component	company*	short description
INT-10 (being discontinued)	npi www.npielectronic.com	Breakout box for CellWorks Lite and the 1200 data acquisition board series from National Instruments, with multiple trigger possibilities, additional digital power output for up to 8 valves and connector for the digital bidirectional communication of npi amplifiers
INT-20X	npi	Breakout box for CellWorks Lite E and the Lowcost E-series data acquisition boards
VD-24	npi	Universal valve controller for up to 24 valves, low noise and valve heat up reduction technology

BPS-8/4	ALA www.alascience.com	Bath perfusion system for 8 or 4 valves, controlled by one of the breakout boxes or the VD-24 valve driver (also available with a stand alone controller)
TEC-03/05-CW	npi	Voltage clamp amplifier with build in I/O unit for Low cost E-series data acquisition boards from National Instruments (optional with digital standard interface INFA)
TEC and SEC amplifiers	npi	All TEC or SEC amplifiers can be supplied optionally with the digital standard interface INFA
Pumps	ISMATEC	Pumps controlled by the serial port COM1-COM8 (PCs) or modem - printer port (Mac)
Polychrom II monochromator and FDU ratiometric system	T.I.L.L. PHOTONICS	Controlled by the serial port COM1-COM8 (PCs) or modem - printer port (Mac)

* to get information about the technical data. For information how to combine peripheral hardware please contact npi.

7.3. Basic software settings using npi hardware

Low cost E-series board PCI-6024E with TEC-03X-CW



name	direction	
	read	write
gain	-	-
filter	-	-
mode: VC/CC	-	-

Connection:

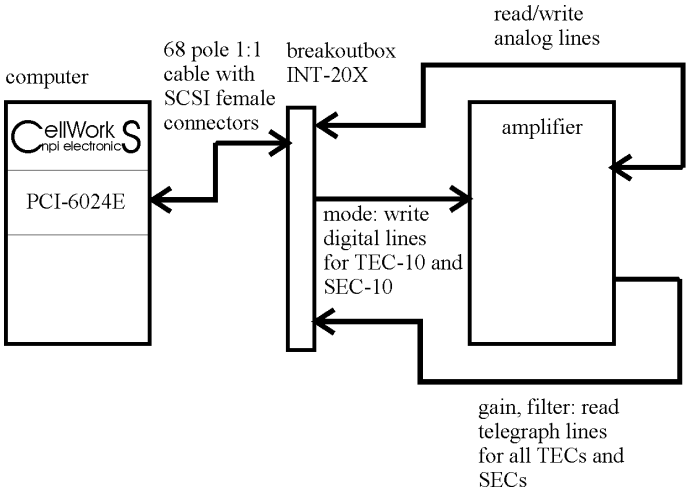
- 68 pole 1:1 cable with SCSI female connectors from the PCI board (inside the computer) to the rear panel connector TO DATA ACQUISITION BOARD (TEC-03X)

Software settings:

parameters	amplifier
Hardware module, subeditor: Amplifier	TEC-03
Interface	Analog In: Telegraph Lines Reading Only
Mode	all buttons OFF
Gain A	Control: OFF, Read: ON, Manual OFF, npi TEC [1/+7] (see range written at the amplifier's front panel), analog input channel: 2
Gain B	all buttons off

Filter A	Control: OFF, Read: ON, Manual: OFF, npi TEC/SEC, analog input channel: 3
Filter B	all buttons off
Attenuation of Ai Signals	Low cost E-series: 1
Digital: Write to Amp	none
Digital: Read from Amp	none
Setup module, subeditor: Software Gain Factors etc	
Ai	❑ **Channel 00**: Gain Factor: 0.001, Sensed Gain: Gain A, Units: µA, Long Names: current ❑ **Channel 01**: Gain Factor: 0.1, Sensed Gain: none, Units: mV, Long Names: voltage
Ao	❑ **Channel 00**: Gain Factor: 10, Long Name: Voltage out, short name: Vo ❑ **Channel 01**: normally not used in this configuration

Low cost E-series board PCI-6024E with breakout box INT-20X telegraph reading and mode control



name	direction	
	read	wite
gain (all)	+	-
filter (all)	+	-
mode:		
VC/CC (TEC-10)	-	+
RPEL (TEC-10)	-	+
RCEL (TEC-10)	-	+
BR (SEC-10)	-	+
REL (SEC-10)	-	+

Connection SEC/TEC:

- 68 pole 1:1 cable with SCSI female connectors from the PCI board (inside the computer) to the front panel connector PCI E SERIES BOARD (INT20X)
- BNC cable from digital line 0 (Do0) (front panel breakout box INT-20X) to connector RPEL (rear panel TEC)
- BNC cable from digital line 1 (Do1) (front panel breakout box INT-20X) to connector VC (rear panel TEC)
- BNC cable from digital line 2 (Do2) (front panel breakout box INT-20X) to connector CC (rear panel TEC)
- BNC cable from digital line 3 (Do3) (front panel breakout box INT-20X) to connector RCEL (rear panel TEC-10)
- BNC cable from analog input channel 0 (Ai0) (front panel breakout box INT-20X) to connector - CURRENT OUTPUT (front panel SEC/TEC)

- BNC cable from analog input channel 1 (Ai1) (front panel breakout box INT-20X) to connector – POTENTIAL OUTPUT (front panel SEC/TEC)
- BNC cable from analog input channel 2 (Ai2) (front panel breakout box INT-20X) to connector - CURRENT SENSITIVITY (front or rear panel SEC/TEC)
- BNC cable from analog input channel 3 (Ai3) (front panel breakout box INT-20X) to connector FREQ. MON (front or rear panel SEC/TEC)

For some SEC only:

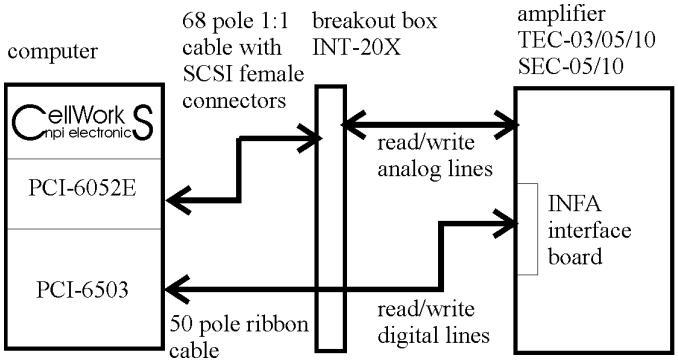
- BNC cable from analog input channel 4 (Ai4) (front panel breakout box INT-20X) to connector MONITOR OUTPUTS - FILTER POTENTIAL (rear panel SEC)

Software settings:

parameter	**amplifier**	
Hardware module, subeditor: Amplifier	TEC-03/05/10	SEC-05/10
Interface	Digital Lines: TTL Control, Ai: telegraph reading	Digital Lines: TTL Control, Ai: telegraph reading
Mode	Control: on (button is red), Read: off (button is gray), Manual on, npi T/S 05 old	Control: on (button is red), Read: off (button is gray), Manual on, npi T/S 05 old
Gain A	Control: off, Read: on, Manual off, TEC [1/+7] (see the range written on the amplifier front panel), analog input channel: 2	Control: off, Read: on, Manual off, SEC [1/+7] (see the range written on the amplifier front panel), analog input channel: 2
Gain B	all buttons off	all buttons off
Filter A	Control: off, Read: on, Manual: off, npi TEC/SEC, analog input channel: 3	Control: off, Read: on, Manual: off, npi TEC/SEC, analog input channel: 3
Filter B	all buttons off	if available: Control: off, Read: on, Manual: off, npi TEC/SEC, analog input channel: 4 If not available: all buttons off
Attenuation of Ai signals	1	1
Digital: Write to Amp	PCI-6024E Port A+B	PCI-6024E Port A+B
Digital: Read from Amp	none	none
Setup module, subeditor: Software Gain factors etc		
Ai	❑ **Channel 00**: Gain Factor: 0.001, Sensed Gain: Gain A, Units: µA, Long Names: current ❑ **Channel 01**: Gain Factor: 0.1, Sensed Gain: none, Units: mV, Long Names: Voltage	❑ **Channel 00**: Gain Factor: 0.001, Sensed Gain: Gain A, Units: nA, Long Names: current ❑ **Channel 01**: Gain Factor: 0.1, Sensed Gain: none, Units: mV, Long Names: Voltage

Ao	❑ **Channel 00**: Gain Factor: 10, Long Name: Voltage out, Short Name: Vo ❑ **Channel 01**: usually not used in this configuration	❑ **Channel 00**: Gain Factor: 10, Long Name: Voltage out, Short Name: Vo ❑ **Channel 01**: usually not used in this configuration

Professional interface PCI-6052E with external breakout box INT-20X, additional digital I/O board PCI-6503 and additional INFA interface board inside the amplifier



name	direction	
	read	**write**
gain (all)	+	+
filter (all)	+	+
mode VC/CC	+	+

connection:

- ❑ 68 pole 1:1 cable with SCSI female connectors from the PCI board (inside the computer) to the front panel connector PCI E SERIES BOARD (INT20X)
- ❑ 50 pole 1:1 cable with SCSI1 female connectors from the PCI board (inside the computer) to 50 pole SCSI1 female connector (rear panel amplifier)
- ❑ BNC cable from analog input channel 0 (Ai0) (front panel breakout box INT-20X) to connector - CURRENT OUTPUT (front panel SEC/TEC)
- ❑ BNC cable from analog input channel 1 (Ai1) (front panel breakout box INT-20X) to connector – POTENTIAL OUTPUT (front panel SEC/TEC)

software settings:

Parameters	**amplifier**	
Hardware module, subeditor: Amplifier	TEC-03, TEC-05 and TEC-10	SEC-05 and SEC-10
Interface	Digital Lines: npi Bidirectional	Digital Lines: npi Bidirectional
Mode	Control: on (button is red), Read: on, Manual off (button is gray), npi TEC 5/10	Control: on (button is red), Read: on, Manual off (button is gray), npi SEC 5/10
Gain A	Control: on, Read: on, Manual off, TEC [1/+7] (see the range written on the amplifier front panel)	Control: on, Read: on, Manual off, SEC [1/+7] (see the range written on the amplifier front panel)
Gain B	all buttons off	all buttons off
Filter A	Control: on, Read: on, Manual: off, npi TEC/SEC	Control: on, Read: on, Manual: off, npi TEC/SEC

Filter B	all buttons off	Control: on, Read: on, Manual: off, npi TEC/SEC
Attenuation of Ai Signals	1	1
Digital: Write to Amp	needs additional digital I/O board e.g. PCI 6503, Port A	needs additional digital I/O board e.g. PCI 6503, Port A
Digital: Read to Amp	needs additional digital I/O board e.g. PCI 6503, Port B	needs additional digital I/O board e.g. PCI 6503, Port B
Setup module, subeditor: Software Gain Factors etc		
Ai	❑ **Channel 00**: Gain Factor: 0.001, Sensed Gain: Gain A, Units: µA, Long Names: current ❑ **Channel 01**: Gain Factor: 0.1, Sensed Gain: none, Units: mV, Long Names: Voltage	❑ **Channel 00**: Gain Factor: 0.001, Sensed Gain: Gain A, Units: nA, Long Names: current ❑ **Channel 01**: Gain Factor: 0.1, Sensed Gain: none, Units: mV, Long Names: Voltage
Ao	❑ **Channel 00**: Gain factor: 10, Long Name: Voltage out, Short Name: Vo ❑ **Channel 01**: usually not used in this configuration	❑ **Channel 00**: Gain factor: 10, Long Name: Voltage out, Short Name: Vo ❑ **Channel 01**: usually not used in this configuration

7.4. File and directory structure and management

This chapter describes the CellWorks folder- and file structure.

After installing and starting CellWorks the default user folder CWE default will be created automatically by the program. This folder is absolutely necessary to run CellWorks even if you log-in under a different USER name, because this folder contains the initial file “CWInit” with basic configuration settings.

As all other user folders, “CWE default” contains three sub-folders:

- **Config** contains all module configuration files
- **Data** contains all data files. For each day CW creates a new sub-folder, the “daily” folder, where all data of this day are saved.
- **Export** contains the export data files generated in the Online modules or in the CW Reader. The structure of this folder is similar to the “Data” folder structure

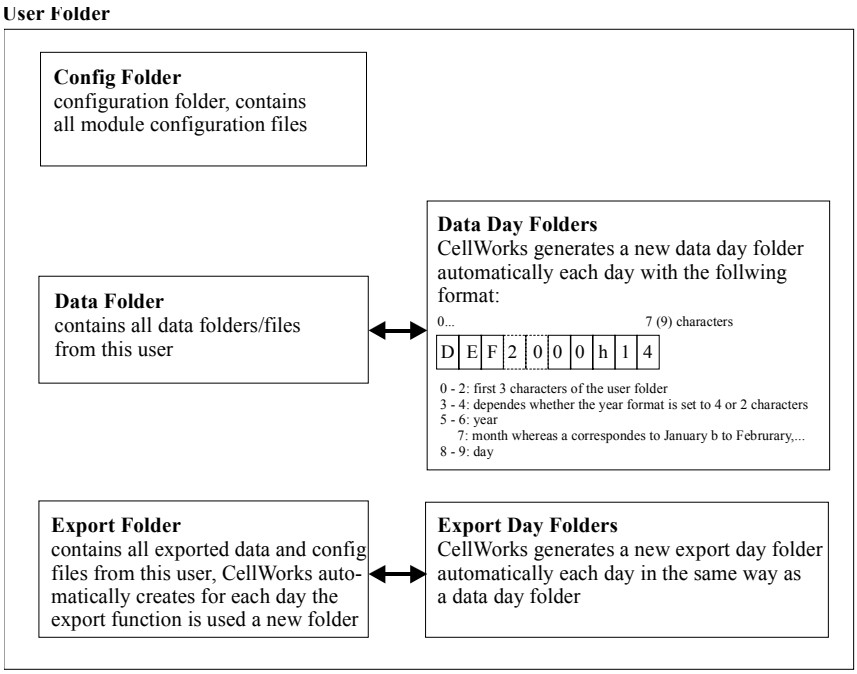


Figure 30: folder structure of a USER

Within the daily folder CellWorks generates four different file types that are all used for reloading data in CellWorks or CellWorks Reader.

- **D file** (e.g. 2000h11E00.D) contains raw data of an experiment
- **F file** (e.g. file 2000h11E00.F) contains the format information of an experiment, e.g. which Ao channels, time base, sweep numbers etc. have been used
- **E file** (e.g. DEF2000h11.E00) does no longer hold information
- **Nme file** (e.g. 2000h11Nme) contains all the names of Solutions, CHARTS, PULSES,...

There is one E, F and D file for each experiment and only **one** Nme file for **all** experiments of one USER during one day.

The data files are created only if a CHART, PULSE sweep or SNAPSHOT sweep is running in the Execution module and the proper options or INSTRUCTIONS (e.g. "Write Pulse to File) have been set. After finishing the current CHART or PULSE sweep,... the data file will be closed. That means the data files are **not automatically** opened if the Execution or any other module is launched, i.e. by default data are **not** saved.

Export files

PULSE data recorded in CellWorks can be exported to ASCII, Igor Text, Autes or Axon Binary format in the Online modules (chapter 5.9). The export data file type is configured in the Online modules. CellWorks opens the same export or a new export file according to the export settings when starting the next sweep. Currently, CHART data can only be exported offline in the CellWorks Reader program (chapter 6).

Config files

Configuration files (Hardware, Setup, Pulses, Charts etc.) are saved by default in USER Config folder.

7.5. Common user interface elements

This chapter describes the elements and methods commonly used in several modules.

Menu bar

Every module header includes a menu bar similar to other Windows or Mac programs with commands, e.g. to load configuration files, to close the module or to print. Shortcuts are available for most of the menu commands, e.g. to close a module press *"control + w"*.

Subeditors

A fundamental concept of the CellWorks user interface are subeditors, which open after double clicking to the corresponding editor field or table. You will find subeditors in many CellWorks modules, and they are indicated by a small red line surrounding the subeditorial field or button.

Graph functions

If you want to change the scaling of any graph axis, click to the corresponding value, type a new value and press <Return>. This can be also done in the Options menu of the Execution module or with an INSTRUCTION command line in the Experiment Editor. The control elements in the upper left corner of a monitor set autoscaling (for either X or Y axis) ON or OFF, specify the scale format and can be used to activate a zoom (in or out) function.

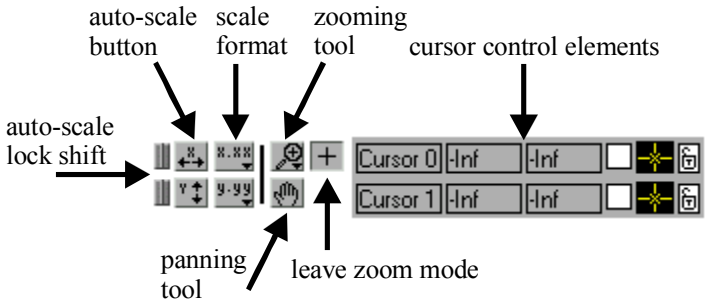


Figure 31: commonly used graph functions

7.6. Server-client structure

Concurrent modules

When multiple modules are opened concurrently, it could happen that conflicting parameters are created by the user. To avoid such problems, the concurrent opening of modules, which are dependent on each other is restricted. For example, when the CW Execution module is open, the CW Chart Editor can be opened only in a “Read only” mode, i.e. the user can check the settings of parameters, but cannot alter them.

Cross reference

The cross reference, i.e. the data exchange between modules, e.g. the PULSE configuration data between the Pulse Editor and the Experiment Editor, is done by element position and not by element name. Thus, elements are always referred by their position in a list and not by their name.

Data interchange

The Execution module is the core module of CW, and it’s relationship to monitors and Online modules, that can be open in parallel, can be explained as a server client structure. The Execution writes predefined protocols and works as server. The Online modules and monitors are the clients of the Execution module. The server is not necessarily synchronized with the clients and does not wait until the clients have done their job. The next figure shows the data flow structure of CellWorks.

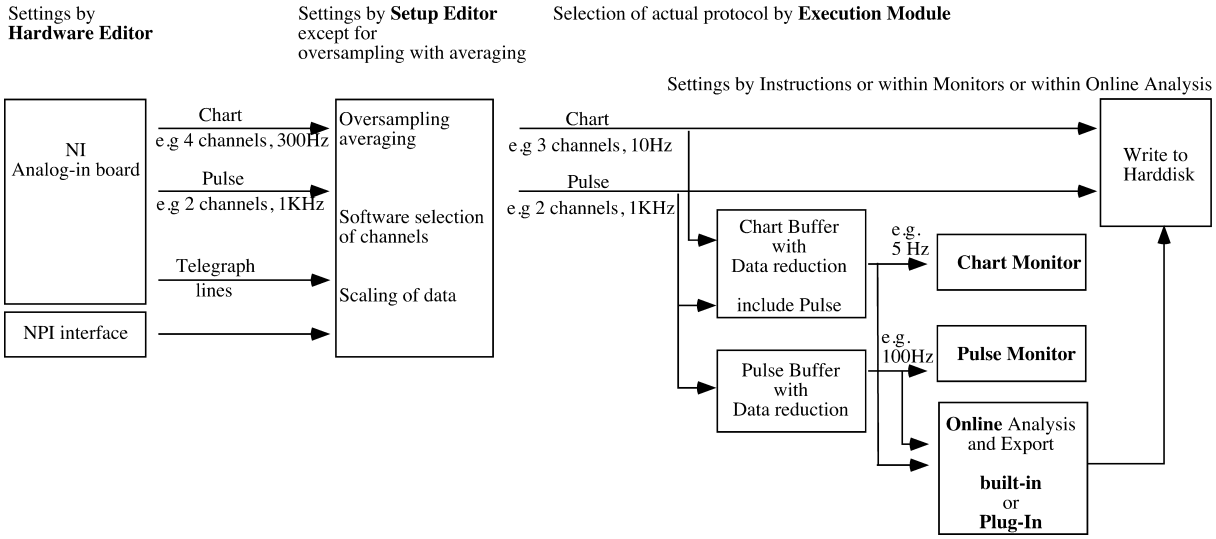


Figure 32: CellWorks data flow structure

7.7. CellWorks Lite for 1200 board series

This chapter describes the differences between CellWorks Lite E and CellWorks Lite as well as the connection and the configuration of the CellWorks Lite hardware.
CellWorks Lite is designed to use the PCI 1200 data acquisition board series from National Instruments. The installation procedure is similar to CellWorks Lite E (chapter 4). The next figures show the hardware connection, the elements of the breakout box INT-10 and a screenshot of the “Analog Main Board” subeditor in the Hardware module. Note that the analog input range of the PCI 1200 data acquisition is restricted to ± 5V, and that the attenuation of Ai Signals must be set to 0.5 in the “Amplifier” subeditor of the Hardware module. Furthermore, one has to take care that the for PCI 1200 “Write to Amp” is performed via “Port A”.

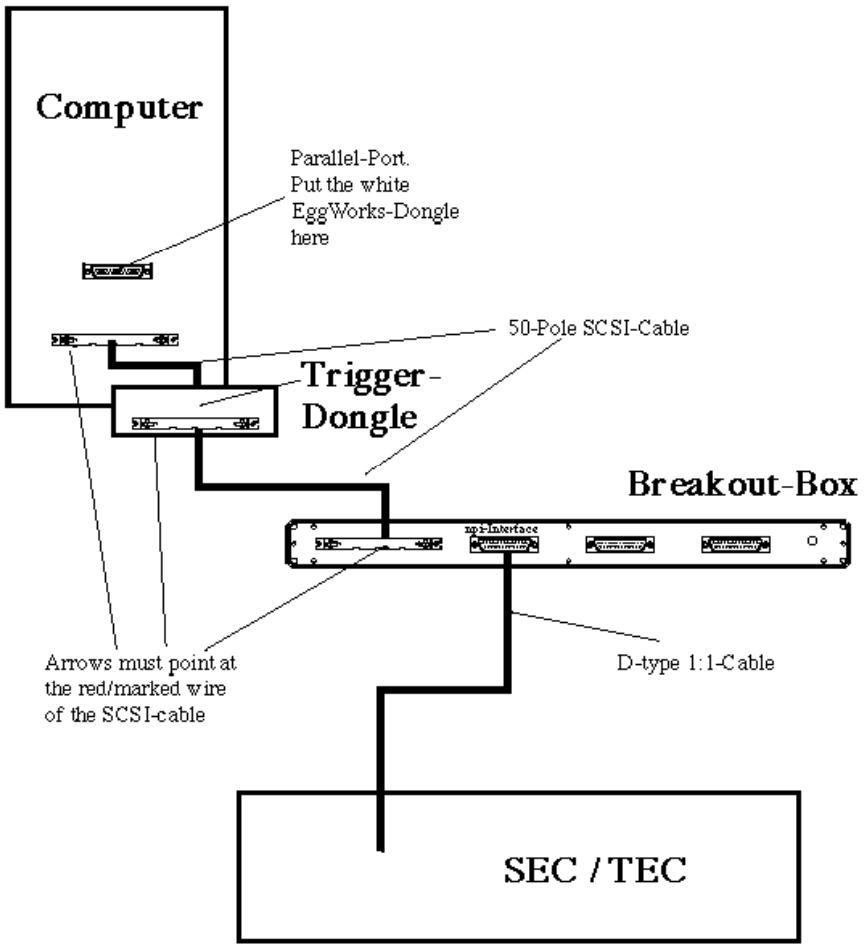


Figure 33: CellWorks Lite hardware connection

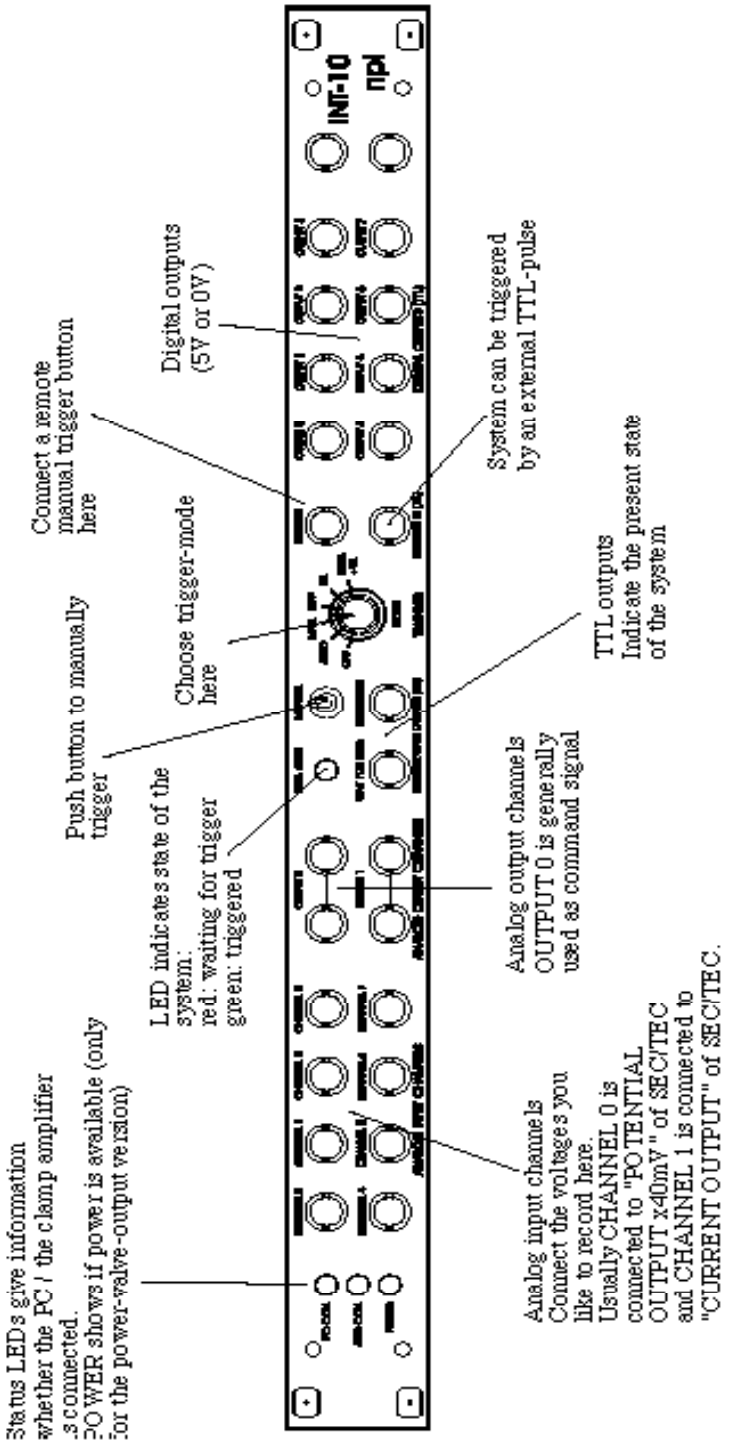


Figure 34: INT-10 breakout box front panel elements

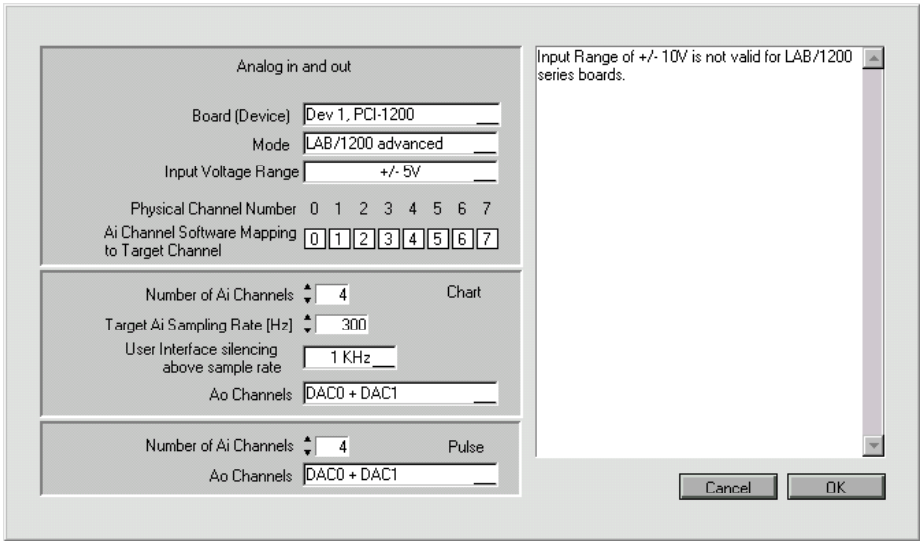


Figure 35: CellWorks Lite analog in and out subeditor

7.8. Keyboard shortcuts

keys	description
ctrl + o	load config file in a module and load data file in the Exe Record module
ctrl + p	print window
ctrl + q	quit module
ctrl + s	save the module config file
ctrl + w	close module
ctrl + shift + d	toggle size of the Exe Record window
ctrl + shift + e	export settings: opens the export settings window in the online module
ctrl + shift + o	options: opens the options window in the Online module
ctrl + shift + r	record file: opens the Exe Record window in the Execution module

7.9. Abbreviations used in this manual

ADC:	Analog-Digital conversation
Ai:	Analog input
Ao:	Analog output
Ch.:	channel
DAC:	Digital-Analog conversation
DAQ:	Data-Acquisition
CW:	CellWorks
CWL:	CellWorks Lite
CWR:	CellWorks Reader
fig.:	Figure
NI:	National Instruments
npi:	npi electronic
Pref(s):	Preference(s)
Ref V:	Reference Voltage
Trig.:	Trigger
TTL:	digital lines (high corresponds to +5V and low to 0V)

7.10. Figures

7.11. Index

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